CODE OF PRACTICE FOR GEOSYNTHETICS AND STEEL MESHES

Foreword

This first edition of the 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.

Reference has been made to BS EN 15381:2008 Geotextiles and Geotextile Related Products – characteristics required for use in pavements and asphalt overlays. This EN sets the standard for manufacturers to produce Geosynthetics with CE marking.

The document references the work of the COST ACTION 348 group on Reinforcement of Pavements with Steel Meshes and Geosynthetics - this work included design modelling and design procedures.

This edition has been written and may be used with reference to the ADEPT document “Guidance on the use of paving fabrics and grids as asphalt reinforcement”. This edition also anticipates the following publication; Interim Advice Note Highway Agency - ‘The Approval Process for the Use of Geosynthetics in Pavements to Control Reflective Cracking’.

This document has been peer reviewed by ADEPT Soils, Materials, Design and Specifications Committee.

The information contained herein is intended to represent industry best practice. No liability is accepted by RSTA for any damages caused to property or personal injury resulting from using the guidance contained within this document.

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1. INTRODUCTION & OVERVIEW

Cracking in asphalt pavements is now recognised as one of the biggest problems faced by highway maintenance engineers. Geosynthetics and steel meshes, also known as interlayers, are a proven approach for extending the life of pavements. When placed between bituminous bound layers these products retard the initiation and propagation of reflective cracking which leads to premature pavement failure.

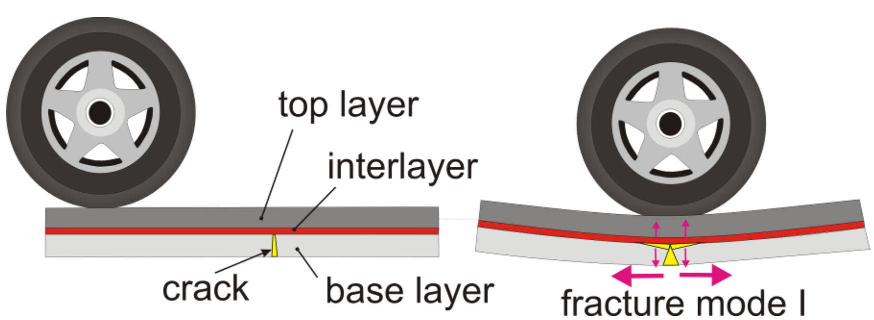
These systems have a long track record of successful use with over 5 million m^2 used in the UK and more than 100 million m^2 installed throughout Europe since the 1980's.Over this period the industry has continuously improved its products, systems and installation techniques and captured evidence of performance. It is worth noting that the majority of UK local authorities have now used these systems as they have grown in acceptance.

This first edition of the Code of Practice (CoP) has been produced by manufacturers and installers to provide highway authorities, designers and principal contractors with essential guidance on the use of geosynthetics and steel meshes, their use, laying techniques and applications.

For clarity this document is solely concerned with addressing pavement defects caused by reflective cracking. Failures and degradation resulting from the following circumstances are **not** addressed:

- Asphalt deterioration
- Sub-grade failure and associated rutting
- Asphalt rutting associated with permanent asphalt strain

The maintenance of roads in the UK has always been a challenge due to heavy trafficking and variable weather conditions. Many types of treatments at, or below, the surface of an asphalt road have been used to extend the lifetime of the road with a view to minimising maintenance costs. Breakdown of the road surface is caused by weathering, movement and fatigue, accelerated by the asphalt's susceptibility to reflective cracking leading to ingress of water, then to potholes and a finally, total breakdown of the surface.



One of the treatments which has been used extensively over the past 25 years in the UK and throughout Europe is the use of an interlayer which is installed within the pavement to intercept the path of a crack propagating through the pavement. These interlayers are usually supplied as a rolled product in grid form (polymer, glass & steel mesh), non woven geotextile (polymer & glass) or a composite and non woven (both glass & polymer). This approach has resulted in significant whole life cost savings through reduced maintenance, a number of ADEPT members have confirmed this to be their experience.

A useful way of comparing the effectiveness of these systems is to express performance in terms of a 'cost life index'. This is the cost per square metre of the work divided by the service life in years. It provides a measure of 'value for money' which the highway authority is achieving. A low 'cost life index' and high 'value for money' result from specifying high-quality materials and workmanship.

Benefits include:

- Maintenance cost reduction.
- Significant extension of road life over conventional surfacing.
- Reduction in asphalt thickness, in some circumstances, saving on material costs
- Reduced environmental impact associated with longer maintenance intervals
- Reduced hidden costs to businesses and the general public through delays caused by road closure and traffic restrictions

These benefits have steadily driven increased utilisation of these products over recent years.

Bituminous bound layers crack in-situ because of their inability to withstand strain, shear and tensile stresses created by a number of factors resulting in one or more of the following outcomes.

- Reflective cracking
- Fatigue cracking
- Differential settlement (often prevalent in road widening schemes)
- Thermal cracking

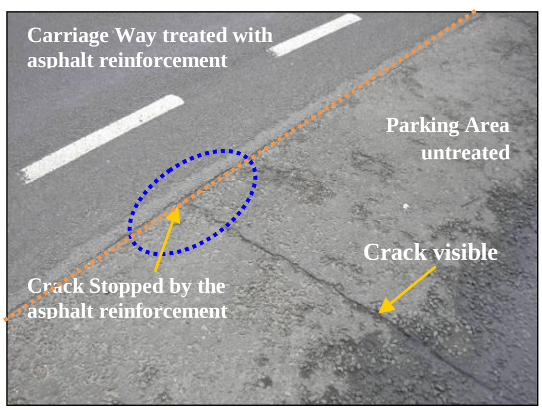
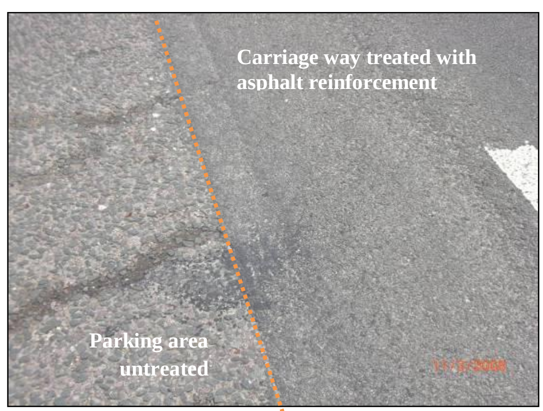


Photo taken in 2008, 5 years after installation



Close up area showing prevention of cracking

The effectiveness and performance of the geosynthetic or steel mesh system is highly dependent on site specific circumstances. The majority of UK pavements have evolved over time and were not originally designed to withstand the weight and increasing traffic volume of commercial vehicles. It has taken many years of careful monitoring to establish the performance of these systems after accounting for the many variables that can influence pavement deterioration, and this work continues.

To obtain the best performance it is necessary to consider a range of variables and based on these carefully select the correct geosynthetic or steel mesh system. Research over the years has addressed and isolated these variables, either through laboratory or site trials and this work has been supplemented via extensive practical experience gained from many thousands of successful installations.

The main functions that have been identified are:

- Reinforcement at low strain – the ability of the material to bind the asphaltic layer together to resist crack propagation in either direction, spanning the potential crack.
- Stress absorption – the ability of the material to absorb transient stress in all directions
- Sealing - prevention of water penetration into lower layers and the avoidance of 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.

One key lesson learned and, often overlooked in the past, is that correct installation of these materials is an absolute necessity. It is imperative that geosynthetics and steel meshes are installed correctly and efficiently to maximise long term performance against reflective cracking. Improvements have been made to the efficiency of the installation by using trained operatives and the correct laying equipment generally resulting in little or no delays to the road surfacing installation. This guide has an extensive section on installation techniques to ensure the optimum performance of the selected system.

The type of damage mechanism causing the cracks to appear at the pavement surface depends on the properties and nature of the pavement structure (e.g. thickness, stiffness etc), the properties of the underlying soil, the traffic characteristics, the climatic conditions and also whether it is new construction or maintenance in the form of relatively thin asphaltic overlays. In the latter case the severity of cracking in the existing pavement structure plays an important role.

A wide range of possible solutions for reflective cracking exist: mill and fill (and overlay), application of thick asphaltic overlays, the use of modified asphaltic mixtures (e.g. with high bitumen content, polymer modified bitumen or composed in such a way that a porous nature is created), the application of an interlayer for stress-absorption or reinforcement systems. Combinations of these solutions are of course also possible. During the design phase of a project, each potential solution needs to be assessed in terms of cost and benefit to life expectancy before deciding on the most appropriate maintenance option.

Manufacturers have responded to the variations in road type, failure mode and the need for efficient installations by modifying their products and systems to suit.

Key product types available are listed below:

- Steel meshes
- Glass grids (may be coated with polymer or bitumen)
- Polymer grids
- Composites (combining polymer or glass grids and non woven textiles)
- Non-woven textiles

A wide range of techniques have been successfully utilised over many years involving different constituent materials, installation practices and design methodologies as illustrated by this CoP.

This document aims to guide and inform designers and end users on the range of products and applications that are available so they are able to make informed project related decisions. It identifies the important aspects for the use, design and correct installation of geosynthetics and steel meshes in bound pavement layers.

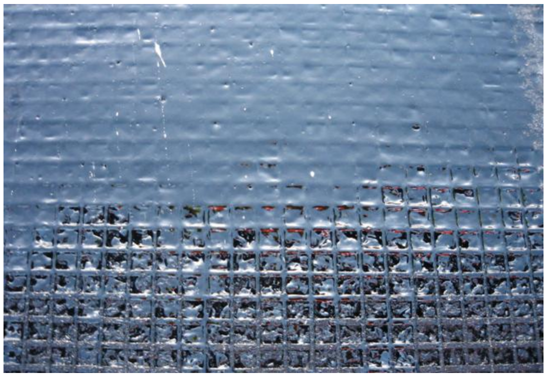
2. GEOSYNTHETIC AND STEEL MESH MATERIALS

a) Types

Geosynthetics and steel mesh products are available in a variety of forms (grids, textiles, composites etc.), and are manufactured from different base materials (glass, polymers, and steel). The following material types are commonly used.

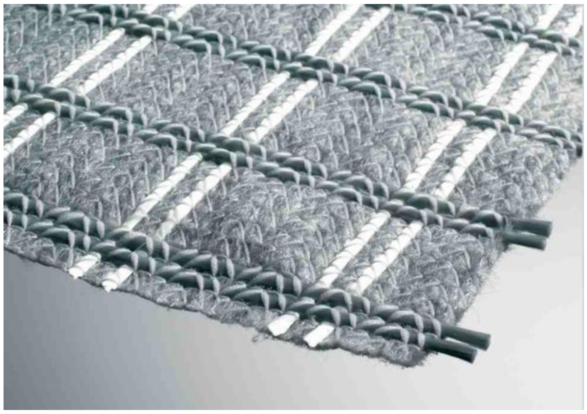
Steel meshes typically galvanised steel wire, double twisted to form a mesh with reinforcing bars at intervals.

Glass grids typically knitted and may be coated with polymer or bitumen or a combination. Some of these materials have self adhesive backing.

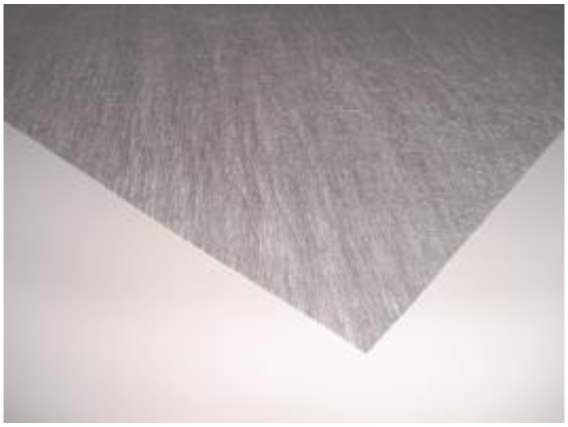


Polymer grids typically punched and stretched polypropylene or knitted/woven polyester. Other polymers are also available but less prevalent.

Composites typically a combination of polymer or glass grids and non-woven textiles combined by lamination or stitching.



Non-woven fabrics typically needle punched polypropylene but polyester and combination using glass fibres are also available.



Geosynthetics and steel meshes must be compatible with the asphalt to ensure the integrity of the system. They must be stable and durable both to withstand the rigors of the paving operation and provide functionality for the desired design life.

b) Quality Assurance

All the materials listed in 2 a) above should be manufactured under quality controlled conditions and should be CE marked in accordance with BS EN 15381:2008 (specific product details may be obtained directly from the relevant manufacturers). Quality assurance of any product used is required to ensure a high standard of installed, long term, product performance. The RSTA Geosynthetics and Steel Meshes Sector members (see Appendix D) are fully committed to the utilisation of quality manufactured products and must operate quality management systems in accordance with the requirements of BS EN ISO 9001 (2008).

c) Control of Substances Hazardous to Health (COSHH)

All materials utilised must comply with COSHH Regulations 2002. Installation contractors must be provided with COSHH datasheets relating to the hazards to health represented by the use of materials or equipment.

3. SITE CONDITIONS AND ASSESSMENT

a) Existing Site Condition and History

Before a geosynthetic or steel mesh solution can be proposed every project should be carefully assessed and, in particular, information should be collected on a range of site specific conditions. It may be the case that issues exist that require other forms of treatment prior, or in preference, to geosynthetics or steel mesh.

As indicated above, it must be remembered that roads have, in many cases, evolved rather than been designed and there are many differing related pavement construction types and failure mechanisms. It is therefore important to make careful observations and measure existing site conditions to help assess the potential failure mechanism so the most appropriate solution can be recommended.

As a general consideration associated with all pavement construction, water plays a significant role in carriageway deterioration. Water table and drainage issues must be identified and dealt with prior to pavement remedial works to prevent premature failures. Roads built through cuttings in rural areas are particularly susceptible to drainage problems. Any site should be examined for signs of upward pumping of groundwater or excessive movement and structural instability. If the pavement is structurally unstable or hydraulically compromised, the designer should first address the structural and groundwater issues before the solution to any remaining reflective cracking problem can be considered.

In order to make a fully informed evaluation of a reflective cracking problem there are number of key pieces of information which must be collected or recorded.

Information on surface cracking should be recorded as follows*:

- Number and length of cracks greater than 5 mm with spalling and bifurcation
- Number and length of cracks less than 5mm wide
- Location of cracks (e.g. only in wheel tracks or over the entire road surface)
- Photographs are obviously very useful (e.g. 1m from road surface)

*(Guidance in the Design Manual for Roads and Bridges, Volume 7, Section 3, Part 3, HD 30/08 Pavement Maintenance Procedure may also be helpful).

Other information required on the existing conditions and history includes:

- Traffic characteristics (number, type of vehicles, speed)
- Type and details of existing road construction
- Location of service trenches
- If relevant, the temperature variations in time (day, night, season)
- Pavement and soil properties
- Drainage and groundwater information (see above)

During the site survey care should be taken to observe not only the failed carriageway but tell tale signs in other areas. For example linear cracking may not be reflective cracking but may be due to service pipe failure or settlement due to previous road widening.

In addition to the information above a falling weight deflectometer could be employed to determine the effective modulus of the existing pavement, although care should be taken with the interpretation of these results.

As indicated above it is important to have an understanding of the type of existing road construction as this may give valuable clues about the potential failure mechanism.

Flexible Composite Pavements

Flexible composite pavements often display reflective cracking from construction joints. Such pavements are constructed in differing forms, with some internally reinforced with steel mesh, some incorporating connecting dowel bars and others with no reinforcement at all. Most flexible composite road bases will have been installed with expansion joints which commonly initiate cracking in flexible overlay materials. Another common problem associated with these pavements is settlement of the underlying slabs resulting in the formation of voids, which can lead to rocking movement and/or some slabs fracturing under the stress. Significant vertical shear movement must be alleviated prior to installation of any geosynthetic or steel mesh material or early failures will occur.

Pavement Quality Concrete/Cement Bound Materials/Lean Mix Road Base

Roads constructed using a lean mix road base display reflective cracking in a similar manner to composite roads, although the material is not jointed, reinforced or dowelled. Lean mix roads may suffer with some slabs fracturing into irregular slabs and acting independently from the rest of the carriageway.

Flexible Pavements

Flexible pavements can fail for a number of reasons, it is critical that the correct mode of failure is identified so that appropriate remedial action can be taken. Flexible pavements with weak foundations often display alligator cracking in patches. Ruts can be present in conjunction with areas of alligator cracking where carriageways have sub-standard bearing capacity for imposed traffic loadings. Many rural carriageways also display edge deterioration mainly caused by over-run.

Sett Paved Carriageways

In many areas of the UK older roads were originally constructed using setts (cobbles) which have been subsequently overlaid with bituminous materials. The presence of setts can lead to de-lamination and cracking of overlay materials. Care must be taken to ensure that setts are stable.


Reflective cracking from concrete bays


Reflective cracking from thermal movement


Reflective cracking from expansion joints


Cracking from utility trench


Surfacing failure caused by underlying setts


Alligator cracking due to structural failure

b) Determine Required Performance and Limitations

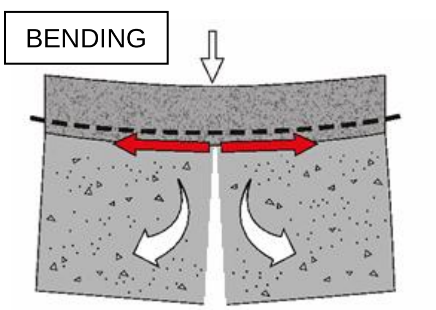
Clearly in addition to the existing conditions the choice of solution will be influenced by practical and future limitations, performance requirements and expectations. The following points should be considered:

- The required life of the solution. For example the acceptable level of crack over a specific time table (say 10% of the original cracking in 10 years)
- The presumed life of any alternative solution. For example plane & overlay with no geosynthetic or steel mesh
- Any practical limitations on overlay thickness (ironwork, kerb lines, drainage etc)
- If installation is to take place on a planed surface, the proposed coarseness of the milled or planed surface will be required as may influence choice of solution.
- Details of any other planned works which will impinge on, or compromise the chosen solution
- Details of any likely changes in traffic characteristics with time.
- Any limitations on carriageway possessions in terms of time or space.

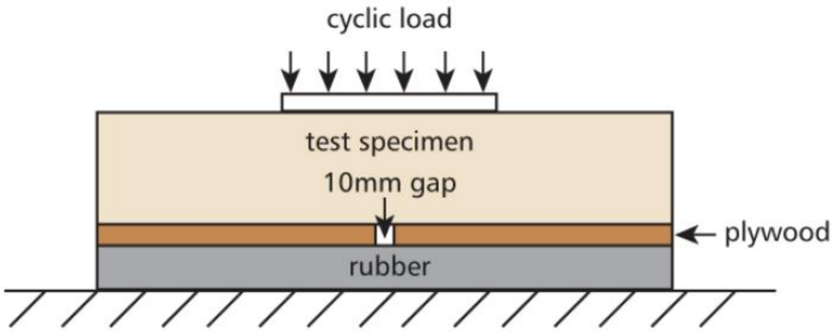
Furthermore, it is considered desirable that parameters which give an indication about road user costs and driving comfort are provided as part of the output.

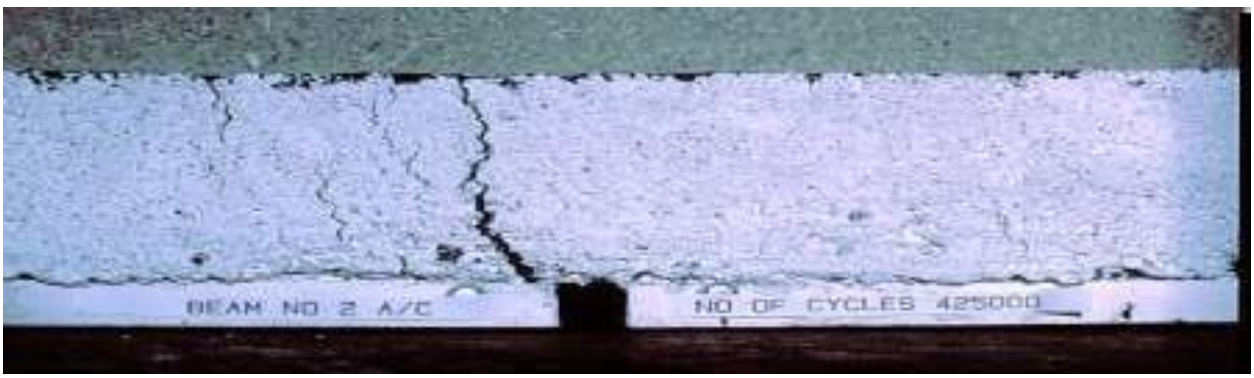
c) Reflective Cracking Failure Modes

Reflective cracking generally results from one of three types of pavement movement, bending, shear or thermal.

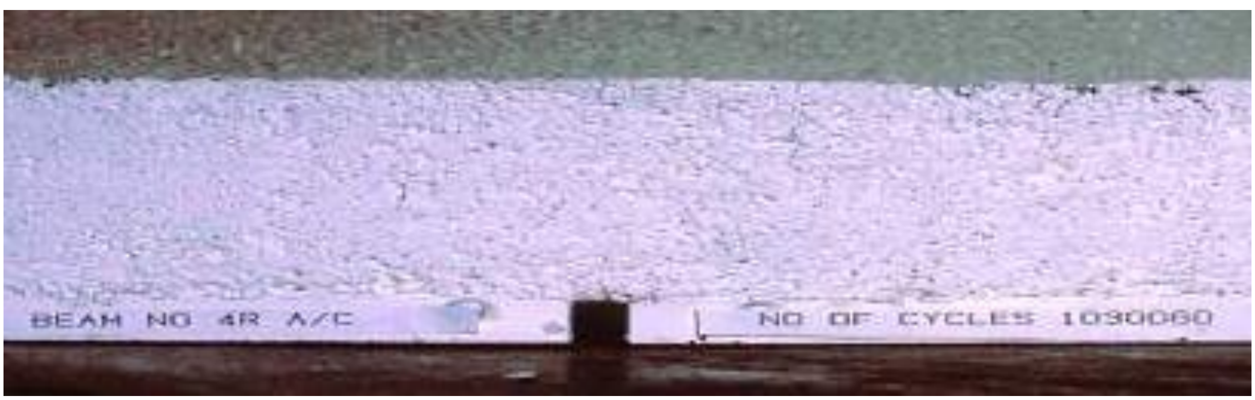


Bending: This mode of failure is relatively common and is well understood. It has been simply recreated via several laboratory models to test a range of materials. A typical model for this type of test is illustrated below using a geosynthetics interlayer. . (Note: the asphalt has been painted white to facilitate crack detection)

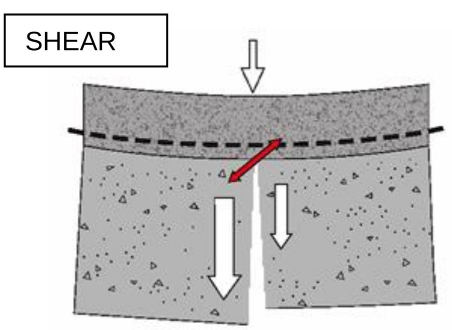




Unreinforced = 425,000 cycles = significant crack

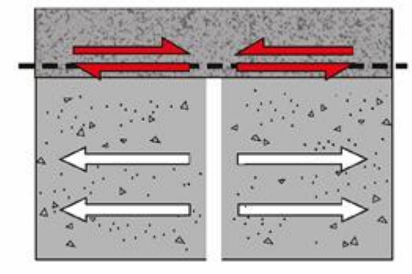


Reinforced = 1,090,000 cycles = no open crack



Shear: This is generally accepted to be the most difficult mode of failure to accommodate and if significant vertical shear movements (> several mm) are present then geosynthetics and steel meshes are unlikely to prevent reflective cracking for any length of time. It is generally recommended that other remedial works are undertaken in order to remove/reduce the shear movements prior to treatment. This is also a very difficult mode of failure to model successfully in the laboratory although some modelling has been undertaken.

THERMAL



Thermal: This mode of cracking is not as prevalent in the UK as some other countries but has been noted. This is a failure mechanism that can be treated successfully with a range of solutions although as movements can be cyclic, consideration should be given to the type of geosynthetic or steel mesh employed. Thermal, in-line, movement is relatively simple to model in the laboratory as indicated below.

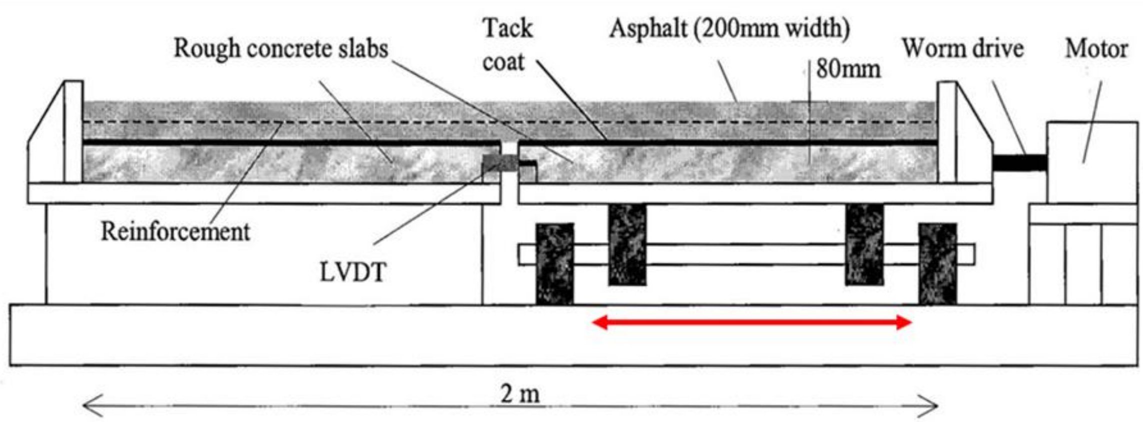
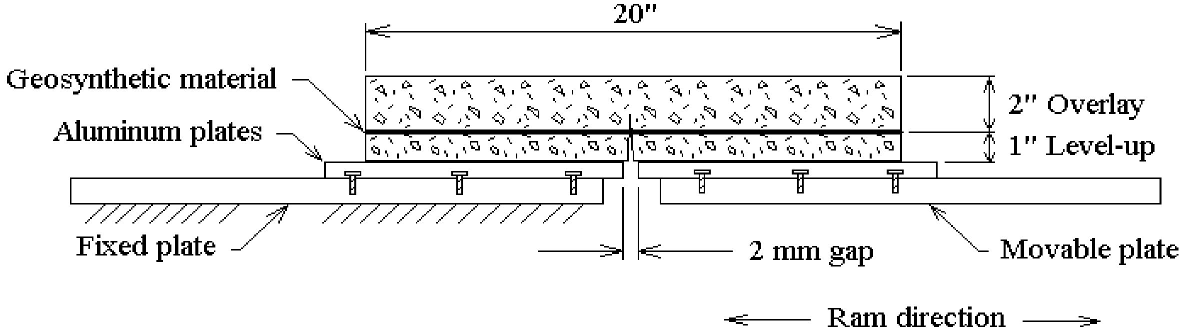


Figure 42: The Thermal Crack Simulation Apparatus



d) <u>System Selection</u>

As indicated in Section 2) above there are many types of geosynthetics and steel meshes in use and there are also many ways in which to categorise these materials but in terms of design philosophy related to reflective cracking they tend to be split as follows:

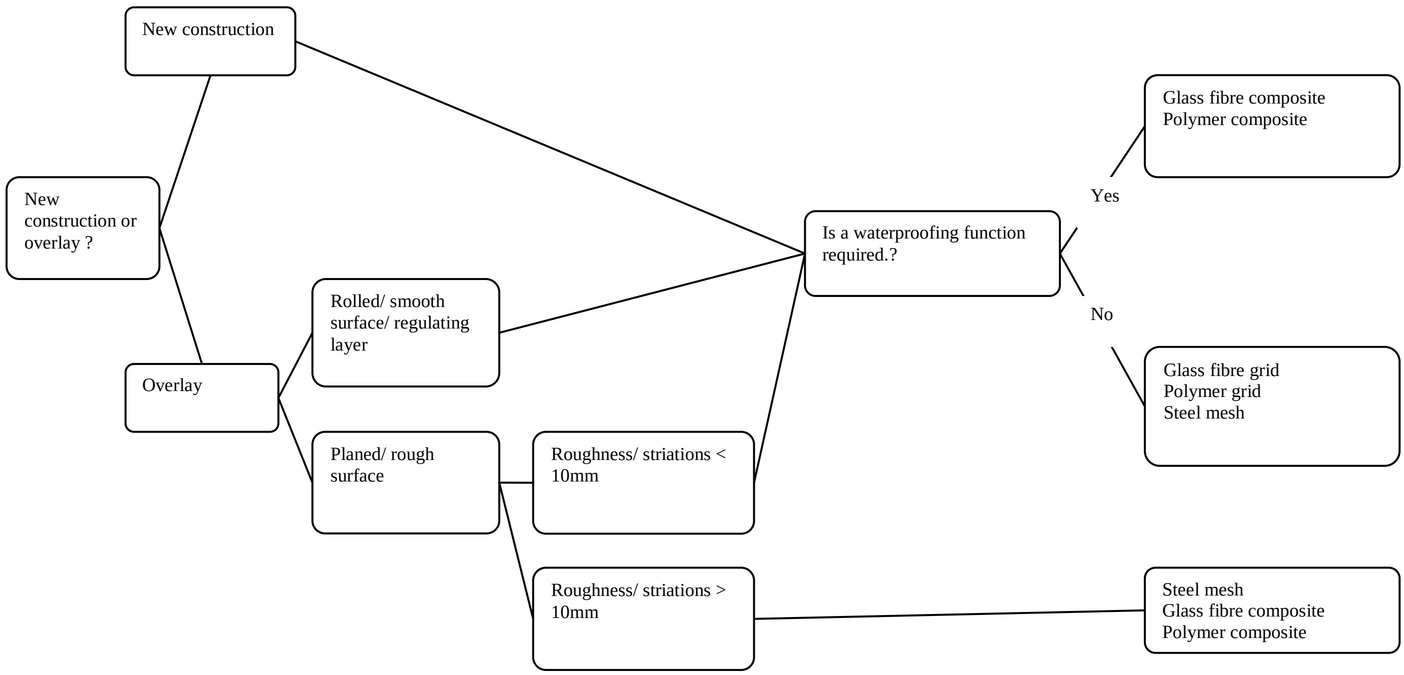
- Those which permit intimate contact between the overlay and the underlying asphalt or concrete and rely on reinforcing the upper layer to inhibit crack propagation
- Those which provide a change in horizontal stiffness between pavement layers thus reducing stress transfer between upper and lower layers. This is often known as the SAMI effect (Stress Absorbing Membrane Interlayer)
- Those which, via the use of composite materials, provide both of the above beneficial effects

It is of note that success has been achieved with all three of the above methods and associated materials and given the complex nature and particular importance of site specific information, it is therefore strongly recommended that the advice of individual manufacturers and installers is sought regarding the suitability of their products and systems to particular project conditions.

However, by way of assistance in this regard, and in addition to the information requested in sections 3a and 3b above, it is suggested that the proposer of a geosynthetic or steel mesh solution should be asked the following questions:

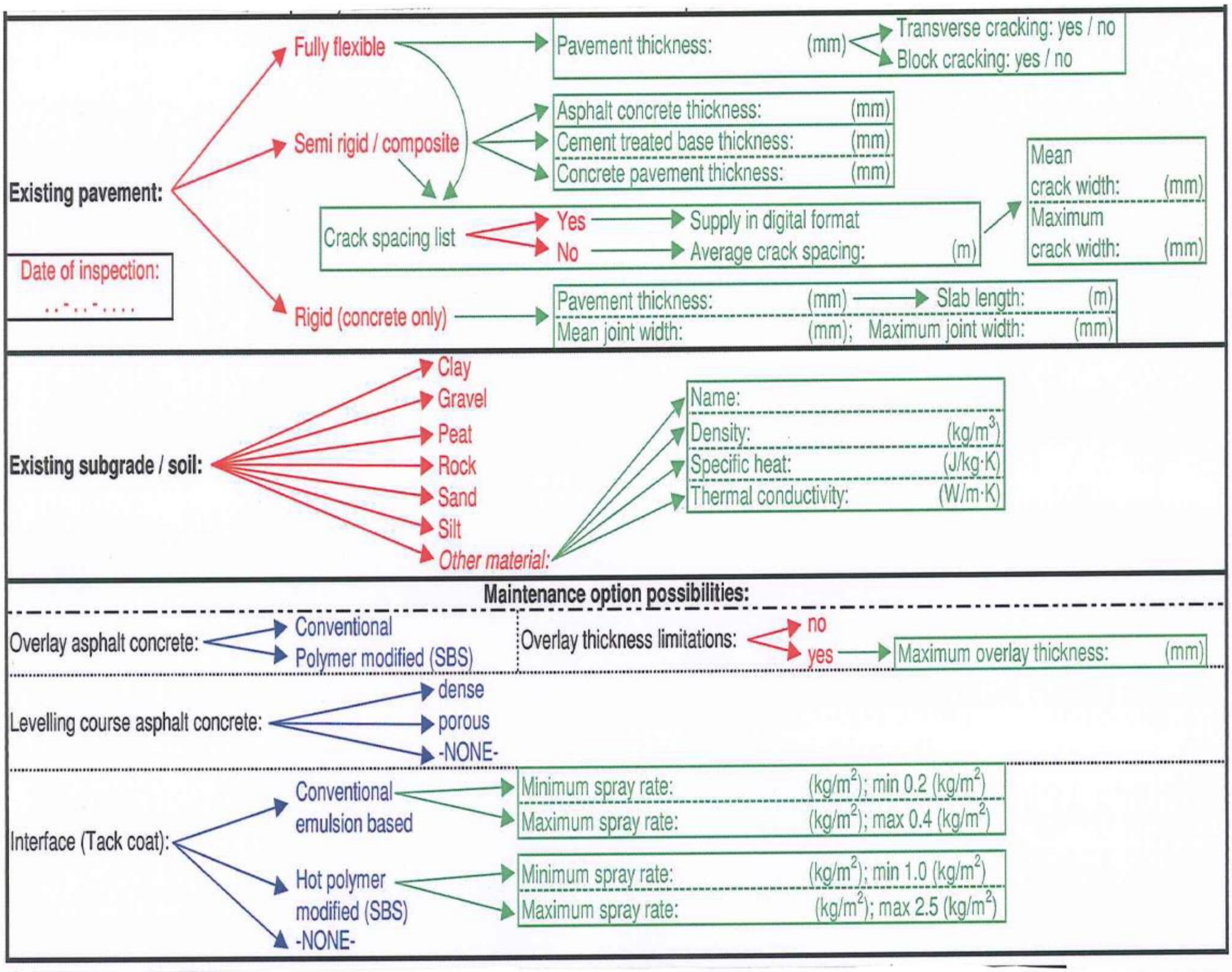
- What is the mode of failure and cracking mechanism prevalent at the site and how will the proposed solution address this?
- What are the required mechanical and durability characteristics of the geosynthetic or steel mesh and how are these to be specified? Any specifications should generally conform to accepted (European) format, where the minimum level of product description is according to international standards (e.g. CEN, ISO).
- How does the geosynthetic or steel mesh interact with surrounding asphalt mixtures in order for the system to function, including details of any mechanism of stress relief required (SAMI)?
- How has the performance of the particular geosynthetic or steel mesh system been validated? (e.g. long term usage, monitoring field data, laboratory research)
- What is the whole life cost benefit of the utilisation of the system for the project in question?
- How will the geosynthetic or steel mesh be removed at the end of its working life and what are the recycling characteristics of the system?
- What are the particular installation requirements associated with the proposed system? (e.g. regulating layer, minimum overlay thickness, particular type and quantity of tack coat etc) See section 4.

The flow chart below is intended to help the designer with the system selection process:



e) Design

As indicated above, due to the large number of geosynthetics and steel meshes available, with their individual properties, there is not a universally agreed design method available to the industry at this time. However a small number of manufacturers and associated designers have developed bespoke design packages which are available on request. For assistance in this regard please consult with RSTA member organisations. The following design input sheet may be of assistance with design input parameters or generally in the process of system selection.


Existing pavement:
Date of inspection:
Fully flexible
Pavement thickness: (mm)
Transverse cracking: yes / no
Block cracking: yes / no
Semi rigid / composite
Asphalt concrete thickness: (mm)
Cement treated base thickness: (mm)
Concrete pavement thickness: (mm)
Crack spacing list
Yes
Supply in digital format
No
Average crack spacing: (m)
Mean crack width: (mm)
Maximum crack width: (mm)
Rigid (concrete only)
Pavement thickness: (mm)
Slab length: (m)
Mean joint width: (mm); Maximum joint width: (mm)
Existing subgrade / soil:
Clay
Gravel
Peat
Rock
Sand
Silt
Other material:
Name:
Density: (kg/m³)
Specific heat: (J/kg·K)
Thermal conductivity: (W/m·K)
Maintenance option possibilities:
Overlay asphalt concrete:
Conventional
Polymer modified (SBS)
Overlay thickness limitations:
no
yes
Maximum overlay thickness: (mm)
Levelling course asphalt concrete:
dense
porous
-NONE-
Interface (Tack coat):
Conventional emulsion based
Minimum spray rate: (kg/m²); min 0.2 (kg/m²)
Maximum spray rate: (kg/m²); max 0.4 (kg/m²)
Hot polymer modified (SBS)
Minimum spray rate: (kg/m²); min 1.0 (kg/m²)
Maximum spray rate: (kg/m²); max 2.5 (kg/m²)
-NONE-

4. INSTALLATION

The planning and organisation to address health, safety and environmental issues must commence as soon as an order is received. The Principal Contractor must comply with the Construction Design and Management Regulations 2007 (CDM) and therefore Principal Contractors should be encouraged to follow the advice in the relevant approved code of practice as they have the responsibility under the new version of the regulations for initiating the framework for safe working practices. This will enable the Principal Contractor to plan and prepare the information and documentation necessary to ensure the specific hazards are identified on the various sites and the level of risk that is envisaged. This must take into account the nature of the site, the materials to be used, the traffic management requirements and any special health, safety and environment issues that are evident. It is the responsibility of the installer to ensure the correct information is provided in a timely manner to the appropriate people.

a. Selection of appropriate installation contractor

The effective use of geosynthetics and steel meshes in bound pavement layers is well established. However, it is essential that they are installed correctly as this is critical to their future performance. Unless the customer has extensive installation experience of the geosynthetic or steel mesh specified, it is strongly advised that a competent specialist contractor is employed to undertake the installation. Installation by the asphalt surfacing contractor is not usually satisfactory because the operatives will be unfamiliar with the process, they are unlikely to have the necessary skills or qualifications or the correct equipment to ensure correct installation.

The performance of the geosynthetic or steel mesh is strongly influenced by the quality of the installation hence the specialist sub-contractor must be chosen with care. The specialist sub-contractor must be able to demonstrate that they employ operatives with substantial experience in this work and that they will use good quality, well maintained, purpose-made installation equipment. The specialist sub-contractor must also operate a quality management system in accordance with BS EN ISO 9001 and be registered with a certification body for the installation of asphalt geosynthetics or steel Meshes. The client should ensure that the chosen contractor is suitably experienced to install the specified geosynthetic or steel mesh.

Geosynthetic and steel mesh installers must be registered to National Highway Sector Scheme 13 and should be members of the RSTA Geosynthetics and Steel Meshes Sector.

b. Planning the Execution of the Work

Installation of the geosynthetic or steel mesh will usually be scheduled to take place immediately prior to the asphalt surfacing. Generally the geosynthetic or steel mesh should not be left exposed for extended periods. The time allowed for installation will depend on the programme and site constraints. For example, installation over a large unobstructed rectangular area will be rapid whereas if the site is an irregular shape or access is poor, installation will be slower. Provided an experienced specialist sub-contractor has been selected, installation of the product should not normally delay the surfacing works. As with all site operations, planning the execution of the work should take place well in advance of on-site commencement.

c. Site Preparation

The preparation required will vary according to the type of geosynthetic and steel mesh material to be installed. Textile backed geosynthetics, e.g. non woven fabrics and composite grids, are installed onto a bituminous bond coat sprayed onto an existing clean bituminous or concrete surface, a well planed surface without pot holes or loose material or a newly laid bituminous surface which must have cooled to ambient temperature. The receiving surface must be clean, dust free, relatively dry and must be free from standing water. All potholes must be made good and any cracks greater than 5mm wide must be sealed. Self adhesive geosynthetics should only be laid on smooth, even surfaces and generally should be installed onto a regulating layer, existing surface or new asphalt layer. Self adhesive grids will also require the application of bond coat either prior or post installation and the receiving surface must be thoroughly dry. Steel mesh can be laid onto an existing clean sound surface, or a well planed surface without potholes or loose materials. Steel mesh can be fixed by nailing, slurry or blinding with asphalt. It is recommended that the individual manufacturer is contacted for project specific advice.

d. Bond Coat and Application

For geosynthetics requiring a bond coat for installation, it is vital to understand its importance as follows:-

(1) The bond coat holds the geosynthetic in position during the asphalt paving process.

(2) The bond coat forms a seal between the underlying surface and the overlaying asphalt. Where a backing fabric is present, the heat and compaction of the overlying asphalt will soften the bond coat causing it to thoroughly impregnate the fabric.

It is essential that the correct type of bond coat and the correct rate of spread are specified and that the installer strictly adheres to these specifications.

The use of hot straight run bitumen is recommended by a number of manufacturers because an immediate and effective fixing is achieved and therefore paving over the geosynthetic may take place immediately reducing time on site.

Bitumen emulsions are also employed, although consideration needs to be given to the break (curing) time required. Paving over the geosynthetic must not occur until the emulsion has fully broken (cured). If an emulsion is used the rate of spread must be calculated so that the quantity of residual bitumen (after evaporation of the water) meets the specification.

The bond coat may be polymer modified and consideration should be given to the change in properties that may result.

The bituminous bond coat must be sprayed by a calibrated binder distributor, tested within the past twelve months for conformity to BS1707. The evenness and overall rate of bond coat distribution should be regularly checked on site by carpet tile testing in accordance BS EN 12272 Part 1. The binder distributor should be of appropriate size that the bond coat can be mechanically sprayed to all except the most inaccessible of areas. Ironwork and other street furniture must be masked for protection from bitumen spray.

e. Geosynthetic Installation

The geosynthetic should be applied by a purpose made applicator capable of laying the fabric under tension without wrinkles or creases and brushing it firmly into the bond coat. Rolling out the fabric by hand should be avoided except in the smallest or most inaccessible areas. Considerable care should be exercised to avoid creases in the laid fabric but in the event of a crease occurring this should be removed in accordance with the manufacturer's installation instructions. Dependent on the type of geosynthetic and project limitations either butt jointing or overlapping will be recommended to ensure continuous coverage without gaps and avoid issues that may occur from reduced overlay thickness. Where overlaps are recommended, longitudinal overlaps should be a minimum of 50mm and transverse overlaps should be a minimum of 100mm. Greater overlaps than the minimum are acceptable provided that bond coat has been fully applied under the overlapping material.

At the end of a run the geosynthetic is cut with a suitable implement (e.g. sharp knife or shears) and can similarly be cut around ironwork and removed.

A procedure for an adhesion test which may be included in the specification to encourage the correct installation is provided as Appendix D.

Trafficking of the geosynthetic should normally be restricted to the paving machine and delivery vehicles only. Drivers of delivery vehicles should take care to avoid braking sharply and turning on the geosynthetic. Steel drum rollers should not run over the geosynthetic.

f. Steel mesh installation

The steel mesh shall be unrolled with the outside of the roll facing upwards to keep the concave curvature downwards. Various devices may be used to facilitate the deployment operation, such as a truck or a loader. The steel mesh should be unrolled in close proximity to the final position then if necessary be moved into the correct position by hand. Laps should be 150mm transversely and 300mm longitudinally and tied with wire. A staggered installation should be adopted to prevent overlaps of 3-4 meshes in one point.

Once the rolls are in their final position, the mesh is rolled a minimum of two passes using a pneumatic tyred roller. The roller must cover the entire width of the roll ensuring that the steel mesh conforms to the prepared road surface. Cutting the edge wire may facilitate the flattening of the steel mesh.

The steel mesh should be stretched to remove any curvature before being fixed: the mesh is initially secured at one end with anchors or heavy equipment like a roller which can be used to maintain the mesh in position. The mesh is stretched with a hooked bar attached to a small truck or a loader. After being stretched, the mesh shall be anchored: the first 4m of each mesh roll should be securely fastened. The mesh is then secured with nails, slurry seal or asphalt blinding or as appropriate:

Nailing

Nail the entire panel with a nailing density of 1 nail per square meter including overlap, nailing the single wire strands, rather than the twisted sections. Nails with PVC sleeve should be used on new asphalt.

Slurry Seal

The Steel Mesh is fixed to the pavement by a slurry seal at a rate of at least 17 kg/m2. An amount of 20-22 kg/m2 is recommended for rough surfaces. Slurry seal must be a modified bitumen emulsion; when a minimum 17 kg/m2 is applied the pattern of the mesh is visible through the slurry seal. After hardening of the slurry, traffic is allowed over the mesh at a reduced speed. The slurry seal should not be applied when the ambient temperature is < 5°C and > 30°C or on wet roads and during rain.

Asphalt Blinding

Using a shovel, lay 10-20mm hot asphalt mix onto the road mesh in both wheel paths in front of the paver. This is made easier if the truck is equipped with trapdoors in the tailgate. Care should be taken to ensure that the blinding is continuous; breaks in the blinding strips will cause the mesh to lift up under the paver. Compact the blinding layer in the wheel tracks with a roller or rubber tyred vehicle.

For all three installation techniques the paver must not be allowed to ‘push’ the asphalt delivery truck on the mesh. The delivery truck must either unload into the paving machine and then move away, or, must drive under its own power, just ahead of the paving machine. Care must be taken by drivers of all vehicles on the mesh not to make aggressive turns, stops or starts that could disturb the steel mesh. The minimum thickness of the compacted asphalt mixture on top of the installed mesh is 50mm. Care should be taken to ensure that the mesh does not lift up under the paver.

g. Overlay Application

Asphalt is laid over the geosynthetic or steel mesh in the normal way subject to the points referred to above.

It is important that the correct minimum thickness of overlay is achieved as insufficient thickness is the principle cause of post installation issues and premature cracking. Each geosynthetic or steel mesh material will have a required minimum compacted thickness of overlay; manufacturer’s recommendations should be sought and strictly adhered to in this respect. The minimum thickness of overlay must be achieved in a single lift rather than relying on the cumulative thickness of two or more lifts of asphalt. When laying asphalt over steel meshes a tracked paver may be less likely to cause rucking than a wheeled paver.

SAMI Surface dressing installation methods

Surface dressing techniques have been used for many years but have been greatly improved when a nonwoven interlayer has been included in the construction. Often surface dressing is used on secondary roads and is a quick and cost effective resurfacing solution to cracked and distressed pavements. Installation is similar to the reinforcing geosynthetics where the surface is cleaned, cracks filled and unrolled flat onto a sprayed tack coat followed by one or two layers of chippings of various sizes. The advantage the nonwoven brings is to act as a uniform retention layer for the tack coat preventing thinning of the bitumen. This in turn largely overcomes the problems of loose chippings being plucked from the surface due to lack of bond. In addition the nonwoven provides stress absorption in combination with the bitumen layer i.e. the SAMI effect which in turn increases the life of the road surface.

h. Training

The manufacturer and the installer must demonstrate their personnel are technically competent and provide certificates of training. All site operatives and visitors to site must hold an appropriate CSCS card to demonstrate an understanding of Health and Safety. Machine operators must hold CPCS or equivalent certificates to demonstrate a level of competence.

Training requirements are embodied within the National Highway Sector Scheme 13 which stipulates the minimum training and qualification requirements for operatives and supervisors on site. Operatives and supervisors will be required to hold NVQ for the installation of geosynthetics and steel meshes used in bound pavement layers.

- Operatives must hold NVQ level 2 and RSTA endorsed CSCS cards.
- Supervisors must hold NVQ level 3 and RSTA endorsed CSCS cards.

Supervisors will attend the RSTA Training course on geosynthetics and steel meshes every 5 years and obtain an RSTA Silver certificate as evidence of maintaining competence. It is also recommended that operatives also attend the RSTA training course every 5 years to remain up to date with industry best practice.

The RSTA can assist installation contractors in obtaining NVQ's and RSTA endorsed CSCS cards for operatives and supervisors in accordance with the requirements of National Highway Sector Scheme 13. It is the Association's view that a competent qualified workforce makes a fundamental contribution to achieving a high quality service.

Details of all training courses can be obtained from the RSTA website; www.rsta-uk.org/calendar

i. Traffic Management

Traffic Management will be the responsibility of the Principal Contractor.

j. Health & Safety

RSTA members involved in manufacturing and installing geosynthetic and steel mesh systems take the health and safety of all their operatives and associated personnel seriously. This concern includes others who come into contact with the installation operation whilst in progress and until the geosynthetic or steel mesh is overlaid.

The installer should consult the manufacturer to ensure that appropriate procedures are followed such that the product is installed safely. In this respect it is advised that only experienced installation contractors who have been instructed by the manufacturer should be allowed to install the product

Under the CDM regulations it will be the duty of the Principal Contractor to prepare a detailed health and safety plan for the installation of the works based on the pre-construction information supplied by the installer, client, designers and CDM-coordinator. This must itemise the methods to be employed to overcome identified hazards and risk reduction measures that will be in force on the contract works. The Principal Contractor must also ensure adequate welfare is provided from the start of the contract. Once the works commence all team members must take responsibility for the control of health, safety and environment matters.

The Principal Contractor has additional duties under other legislation to look after the health and safety not only of his own employees but of other persons who work alongside them and also of the passing public. Written specific risk assessments must be prepared which can be used to identify control measures for both physical and chemical hazards. The control measures must be incorporated in the Contractor’s safe system of work which should enhance the safe behaviour of the workforce as well as protect the general public during the various stages of the works. These measures must be communicated to all involved in the project.

Account must also be taken of environmental factors including pollution from fumes, noise and dust etc. Disposal of waste and protection from spillage and contamination should also be considered.

5. CONCLUSIONS AND RECOMMENDATIONS

From the work reviewed by the RSTA Committee, it can be concluded that:

- Based on over 25 years of field and laboratory experience geosynthetics and steel meshes are proven to inhibit reflective cracking in bituminous bound pavement layers.
- A range of effective products and systems are available providing different levels of reinforcement, stress relief and sealing.
- Correct installation is of paramount importance to the effective performance of all these systems.
- Observing, assimilating and recording a wide range of factors which influence the behaviour of a road surface is key to understanding the failure mechanism and ultimately ensuring the correct system selection.
- No single design method is universally accepted for design of pavements with geosynthetics and steel meshes in bituminous bound layers although a number of options exist, mainly on a bespoke product basis.
- It is strongly recommended that clients or their designers should collect the appropriate information and contact RSTA manufacturers and installers to discuss system options, posing the questions suggested in section 3d of this document.

The RSTA manufacturers and installers of geosynthetics and steel meshes are committed to taking the following action;

- To maintain and when required raise standards of product installation.
- To assist BSI committee B/510/02 (Surface Treatments) in the development of national guidance to formalise the advice available on how to use these systems. BS434-2:2006 is to be re-written in 2012 and will cross reference this Code of Practice. BSI Committee B/510/01 (Asphalt) is also considering cross referencing this Code of Practice in BS594987.
- To encourage designers and clients to collect more long-term field data in a uniform way and in sufficient detail such that it can be utilised for the validation of future (analytical) design tools and system performance.
- To encourage clients to include control sections (without geosynthetics or steel meshes) to permit direct comparison with the performance on treated sections.
- To encourage designers and clients to build instrumented pavements to avoid the construction of control sections.
- To work with client bodies in the development of a universally acceptable appropriate design methodology.

APPENDIX A

GLOSSARY OF TERMS

Terminology

Geosynthetic:
Product, at least one of whose components is made from a synthetic or natural polymer, in the form of a sheet, a strip or a three dimensional structure.

Geotextile:
Planar, permeable, polymeric (synthetic or natural) textile material, which may be nonwoven, knitted or woven.

Geotextile, nonwoven:
A geotextile in the form of a manufactured sheet, web or batt of directionally or randomly orientated fibres, filaments or other elements, mechanically and/or thermally and/or chemically bonded.

Geotextile, woven:
A geotextile produced by interlacing, usually at right angles, two or more sets of yarns, fibres, filaments, tapes or other elements.

Geogrid:
Planar, polymeric structure consisting of a regular open network of integrally connected, tensile elements, which may be linked by extrusion, bonding or interlacing, whose openings are larger than the constituents.

Geogrid, woven:
A geogrid manufactured by weaving yarns or elements, usually at right angles to each other.

Geocomposite:
A manufactured or assembled material using at least one geosynthetic product among the components.

Geonet:
A planar, polymeric structure consisting of a regular dense network, whose constituent elements are linked by knots or extrusions and whose openings are much larger than the constituents,

Steel meshes:
Products consisting of steel bars or wires in the shape of a grid, net, netting or fabric. Elements connected by electro welding twisting.

Glass grid
A geogrid made of glass fibres

Paving Fabric
A needle punched delaminating-free nonwoven polymeric fabric treated by heat on one side only

Carbon fibre grid
A geogrid made of carbon fibre yarns

Adhesion
The property by means of which a geosynthetic sticks to the surface of the road and or binder.

Binder
A liquid comprised of bitumen, either in its natural condition or modified in some way (see Modified Binder).

Binder Distributor
A tanker fitted with a spray bar through which the binder is applied to the road surface.

Bond
The adhesion between the binder and either the road surface or the applied geosynthetic.

Bitumen Emulsion
Liquid product in which a substantial amount of bitumen is suspended in a finely divided condition in an aqueous medium by means of one or more suitable emulsifying agents.

Bitumen – Modified
A binder in which the original properties of the base binder have been altered by the addition of “modifiers”. The most common of these are polymers. The resulting binders are often referred to as being “polymer modified”.

Bitumen – Penetration Grade
A bitumen which complies with the requirements set out in BS EN 12591 : 1991.

Bitumen – Road
A viscous liquid, or a solid, consisting of hydrocarbons and their derivatives which are soluble in trichloroethylene, is substantially non-volatile and softens gradually when heated. It is black or brown in colour and possesses waterproofing and adhesive properties. It is obtained by refinery processes from crude petroleum.

BSI
British Standards Institution

Butt Joint
A type of joint where the geosynthetic does not overlap significantly.

Boxed-In
The creation of an even start and finish of adjacent breeds.

C. E. N.
European Standards Organisation.

COSHH
Control of Substances Hazardous to Health.

COSHH Assessment
An assessment relating to the hazards to health represented by the use of materials or equipment.

Cost Life Index
The cost expressed as the cost per square metre per annum of satisfactory life.

Curtains
The canvas or other material surrounding a spray bar to minimise the gap between the bar and the road surface.

Echelon Work
The running of two applicators one behind the other, in such a way as to produce an Accelerated application of Geosythetics over a width equivalent to their combined widths.

Joints
The point at which the geosynthetic is overlapped.

Mask
An adhesive tape or other similar material used to cover cat's eyes, road ironwork, etc, in such a way that, after removal, they are free from binder.

Modified Binder
A binder in which the original properties of the base binder have been altered by the addition of "modifiers". The most common of these are polymers. The resulting binders are often referred to as being "polymer-modified".

NAMAS
National Measurement Accreditation Services.

NATLAS
National Testing Laboratory Accreditation Service.

Polymer
A substance formed, either naturally or artificially, from chemically simpler substances called monomers, which are joined together by chemical (covalent) bonds to produce very large molecules.

Pre - Patching
The remedial measures carried out to make good defective areas of surfacing in advance of installing the geosynthetic

PTR
An abbreviation for pneumatic-tyred roller

QA
An abbreviation for Quality Assurance.

Quality Assurance
A registration given to a contractor or to a product, under a scheme administered by the Department of Trade and Industry, through its agencies.

Sector Scheme
A Quality Assurance Scheme document used in highways construction and maintenance.

Set
A description of the state of a binder which has cooled to road temperature or, in the case of an emulsion, has ‘broken’.

Sprayer
An abbreviation for binder distributor.

Spraybar
The bar, carrying jets, that is fitted to the tanker and through which the binder is applied to the surface.

Tanker
An abbreviation for binder distributor.

APPENDIX B

REFERENCE DOCUMENTS

Design Manual for Roads and Bridges. Her Majesty's Stationery Office, London.

- HD 24/06 Traffic assessment (DMRB 7.2.1).
- HD 28/04 Skidding resistance (DMRB 7.3.1).
- HD36/06Surfacing material for new and maintenance construction (DMRB 7.5.1).
- HD 37/99 Bituminous surfacing materials and techniques (DMRB 7.5.2).

Manual of Contract Documents for Highway Works. Her Majesty's Stationery Office, London.

- Volume 1: Specification for Highway Works (MCHW 1) www.dft.gov.uk/ha/standards/mchw/vol1/
- Volume 2: Notes for Guidance on the Specification for Highway Works (MCHW 2) www.dft.gov.uk/ha/standards/mchw/vol2/

BRITISH STANDARDS INSTITUTION (2008). Published Document *BS EN 15381 2009*. British Standards Institution, London.

BRITISH STANDARDS INSTITUTION (2000). Bitumen and bituminous binders – Specification for paving grade bitumen. *BS EN12591: 2000*. British Standards Institution, London.

BRITISH STANDARDS INSTITUTION (1989b*). Specification for hot binder distributors for road surface dressing. *BS 1707: 1989*. British Standards Institution, London.

BRITISH STANDARDS INSTITUTION (2007*). Bituminous Mixtures *BS EN 13108 Parts 1-4: 2007*. British Standards Institution, London.

DEPARTMENT OF TRANSPORT (2001*). Safety at street works and road works – A Code of Practice. Her Majesty's Stationery Office, Norwich.

* Current at time of publication; latest version to be used

HOUSE OF COMMONS (1974). Health and Safety at Work, etc., Act 1974. Her Majesty's Stationery Office, London.

HOUSE OF COMMONS (1988). Control of Substances Hazardous to Health (COSHH) Regulations 1988. Her Majesty's Stationery Office, London.

HOUSE OF COMMONS (1991). New Roads and Street Works Act 1991. Her Majesty's Stationery Office, London.

HOUSE OF COMMONS (1994). Construction (Design & Management) Regulations 1994. Her Majesty's Stationery Office, London.

Dr JOHN READ & DAVID WHITEOAK (2003) The Shell Bitumen Handbook – 5th Edition. Shell Bitumen UK, Chertsey.

COST ACTION 348 reinforcement of pavements with steel meshes and geosynthetics, symposium, Egham, Surrey, 16th March 2006, www.cost.eu

BRITISH STANDARDS INSTITUTION Bitumen and bituminous binders – Framework for specifying cationic bitumen emulsions. BS EN 13808. British Standards Institution, London.

DEPARTMENT OF TRANSPORT (2006*). Traffic signs manual, Chapter 8:
Traffic Safety Measures and Signs for Road Works and Temporary Situations. Her Majesty's Stationery Office, London.

BS 434 Part 2:2006, Bitumen Road Emulsions, Part 2 Code of Practice for the use of cationic bitumen emulsions on roads and other paved areas. British Standards Institution, London.

BS 594987:2010, Asphalt for roads and other paved areas. Specification for transport, laying, compaction and type testing protocols. British Standards Institution, London.

APPENDIX C

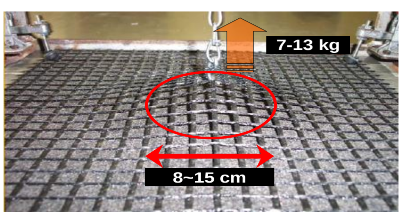
CONSTRUCTION QUALITY CONTROL TESTING

ADHESION TEST PROCEDURE

The contractor shall test to the satisfaction of the Engineer that adequate adhesion exists between the Geosynthetic and the underlying pavement.
1. This test may be carried out on the Geosynthetic after it is placed or it may be carried out on a minimum one square metre sample cut in a square shape.
2. Place the Geosynthetic on the surface to be overlaid.
3. Apply adequate vertical pressure to fully activate the bond, e.g. by use of an installation machine, roller or other means approved by the manufacturer/Installer.
4. Insert a hook of a spring balance (fish scale) under the centre of the Geosynthetic sample. Pull the spring balance up until the sample just starts to pull loose and record the gauge reading. In the event that 9kg or more of force is required to pull the sample up from the road surface, sufficient adhesion has taken place and the paving operation may begin.
5.In the event that the sample does not have 9kg adherence, stop installation, identify if the bond to activate the adhesion needs to be improved or if there is a cleanliness, or moisture issue present. Resolve these issues prior to installing the remainder of the Geosynthetic and prior to placing asphalt on top of the Geosynthetic.
6. Verify proper adhesion with this test once every 1,000 m2 or as directed by the Engineer. Draft RSTA Code of Practice for Inhibiting Cracking in Bituminous Bound Layers Using Geosynthetics and Steel Mesh

On-site adhesion validation

On-site adhesion validation



In accordance with the ADEPT guidance note at least two cores shall be taken per 500 sq.m from the finished surface or after the first layer of asphalt has been overlaid as dictated by the site programme. This rate may be reduced on the basis of consistent positive results. The coring shall be done carefully and ensure at least 50mm of the existing road pavement is included below the SAMI/ reinforcing layer. With overlay thickness greater than 160mm, this test should not normally be needed. The cores shall be tested in a UKAS accredited laboratory for shear bond using the torque bond test as described in the Guideline for Thin Surfacing and Tensile Adhesion Test as described in TRL 176.

Tests results shall be provided in a timely manner. The minimum values required depend upon the thickness of asphalt overlay and are as follows (Based upon IAN 96Rev 1 *Guidance on implementing results of research on bridge deck waterproofing).*

Surfacing thickness	**>120 mm[1]**	**120 – 90 mm[1]**	**90 – 60 mm**	**< 60mm**
Tensile adhesion test [2] MPa	0.30MPa	0.50MPa	0.70MPa	0.8
Shear bond test[2] MPa	0.30MPa	0.30MPa	0.40MPa	0.6

Note 1. Where work is soundly executed, the higher values of bond should be readily achieved, and must be seen as beneficial regardless of the overlay thickness.
Note 2. Where significant braking or turning forces are expected or the SAMI used as part of a structural layer over a soft substrate, the values for 90-60mm surfacing thickness should be achieved.
Note 3. Mean of 3 cores.
Note 4. Well compacted asphalt layers and the bond between them will withstand these forces without destruction if properly laid and fully compacted. Should failure occur in or between the asphalt layers at values below these quoted, the asphalt installation is defective and may need replacement. It may be prudent to take additional cores in a case of doubt to enable the SAMI bond to be assessed.
Note 5. The installer may propose for consideration an alternative method of providing evidence of adequate bond in the completed SAMI/reinforcing layer system.

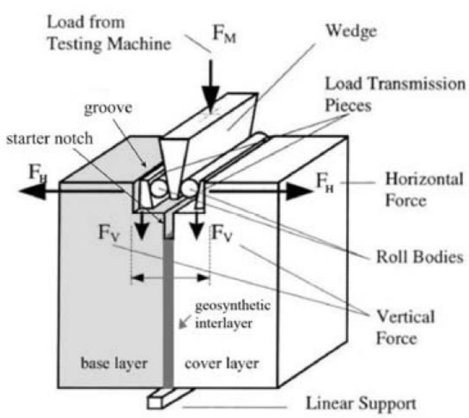
Other test methods that may be considered are the Leutner test method and/or the following Wedge Splitting test.

Leutner Test

The Leutner test method is a laboratory measurement of shear interface properties between asphalt layers. Results are presented and compared for both laboratory prepared specimens and field cores. The standard Leutner test was modified by the introduction of a 5 mm gap into the shear plane to reduce edge damage caused by misalignment of the specimen and specimens that incorporate a thin surfacing material were extended using a 30 mm thick grooved metal cylinder to eliminate dependence of the shear strength on surfacing thickness. The laboratory produced surfacing/binder course combinations incorporating the 20 mm Dense Bitumen Macadam (20 DBM) binder course showed the highest average shear strengths when nothing was applied at the interface and the lowest average shear strengths when the tack coat was applied at the interface. The average shear strength from field cores was found to increase as the class of the road increases for both surfacing/binder course interfaces and binder course/base interfaces.

Wedge splitting method for fatigue testing

Initially developed for fracture tests the wedge splitting test after Tschegg is been developed to measure fatigue crack growth in asphalt interfaces. The principle of this method is shown in Figure 1. The method allows quick assessment of new and existing reinforced pavement and provides a simple quality assurance of the geosynthetics bond strength throughout life of the pavement. The test can be used on circular cores or beams as well as the illustrated cuboid. These cuboids were cut out of drilling cores, so that the interfaces between base- and top-layers were in the middle of the specimen. A symmetrical groove on top of the sample can either be prepared by cutting or which is more common by gluing stone cuboids onto the top of the sample. To assure crack initiation at interface, a so called "starter notch" has to be cut at the bottom of the groove. From here, the crack starts to grow along the interface down to the ground of the sample driven by load. This method has been adopted by the Austrian Highways Authority and is used in a number of European countries



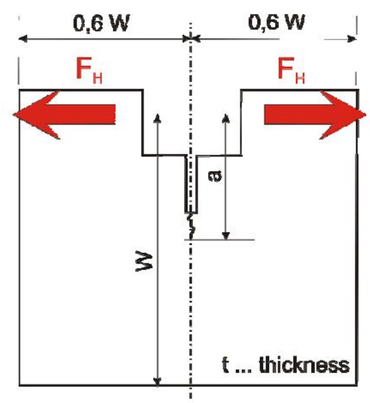


Figure 2: Dimensions of specimen
Cross-section for evaluation

Figure 1: Wedge splitting method after Tschegg (1986) [T1]

Bestimmumng der Kerbzugfestighkeit und der spezifischen Bruchenergie von Baustoffen, Baustoffverbindungen und Verbunwerkstoffen – Keilspaltmethodse ONORM B 3592 2010-11-30 (Wedge splitting test method)

APPENDIX D

REFERENCE PROJECTS

Project/Location	Client	Cracking Mechanism Road Construction	System Installed To Overcome Cracking Mechanism	Constructed
A45 Billing	HA	Expansion and Contraction Reflection cracks over jointed concrete	100kn/m Self adhesive coated glassfibre grid sprayed with Sealoflex PMB binder 200kn/m coated glassfribre geocomposite installed on Sealoflex PMB binder	May 2007
Tulse Hill Lambeth	L.B. Lambeth	Reflection cracks over lean mix base suffering from settlement and traffic loading	100kn/m Self adhesive coated glassfibre grid	2002
Sherrard St Melton Mowbray	Leicester CC	Reflective cracking caused by differential settlement in utility trenches	100kn/m coated glassfibre geocomposite installed on 160/220 Pen grade bitumen	Feb 2011
Uttoxeter Rd Derby	Derby City C	Traffic loading over thin construction causing fatigue cracking and crazing	100kn/m Self adhesive coated glassfibre grid with proprietory tack film eliminating the need to spray bond coats	July 2010
A143 Bungay Norfolk	Norfolk CC	Surface appeared hard and brittle fatigue cracking.	Paving Fabric	2003
A243 Leatherhead Surrey	TFL	Unreinforced concrete slab road base suffering from settlement caused by heavy traffic loading and repairs	200kn/m glassfibre geocomposite	2006

Marine Parade Gt Yarmouth	Norfolk CC	Cyclical high water tables and heavy traffic loading leading to brittle and reflective cracking.	100kn/m glassfibre geocomposite	2007
Middlesex Street Tower Hamlets	L.B. Tower Hamlets	Concrete carriageway showing deteriorated surfacing	100kn/m glassfibre geocomposite	1995
A75 Blackcraig Dumfries and Galloway	Dumfries & Galloway	Soft ground creating severe settlement and cracking	Steelmesh	1999
A4144 Abingdon Rd, Oxford	Oxford CC	Fatigue cracking caused by extremely low CBR values	Steelmesh	2003
A507 Ampthill By Pass	Bedford. CC	Fatigue cracking caused by traffic loading	Steelmesh	July 2001
B7052 Whauphill	Dumfries & Galloway	Settlement cracking over peat sub grade due to heavy trafficking	Steelmesh	April 2003
London Luton Airport	London Luton Air. Operators Ltd	Runway surfacing showing extensive reflective cracking from the expansion and construction joints from PQC	Bitumen coated Polyester geocomposite 50/50 kn/m	1988
BAB Dresden Berlin carriageway	Landesbetrieb Strabenbau Brandenberg NL	Concrete carriageway to be overlaid with asphalt	Bitumen coated Polyester geocomposite 50/50 kn/m	1990
Ochtrup Rosenstrasse Germany	Municipality of Steinfurt	Alligator cracking due to traffic loading	Bitumen coated Polyester geocomposite 50/50 kn/m	1996
Corso Giovanni Agnelli, Torino Italy		Expansion and contraction cracking from concrete slabs	Bitumen coated Polyester geocomposite 50/50 kn/m	2005
Ballymount Ave Upgrade Dublin Ireland	South Dublin CC	Carriageway widening	Polyproperline geocomposite installed with 160/220 Pen grade bitumen	2005

RAF Odiham Hampshire	Defense Estates	PQC Thermal stresses	100kn/m Glasfibre geocomposite installed with 160/220 Pen grade bitumen	2010
A505 Cambridge Rd /Meadowbank Roundabout, Hitchin, Herts	Herts CC	Concrete roadbase overlaid with asphalt, severely cracking by traffic loading	100kn/m Glasfibre geocomposite installed with 160/220 Pen grade bitumen	1999
Stephensons Drive Leics	Leicester C.C	Reflective cracking caused by instability of the concrete paving slabs due to rainwater infiltration	100kn/m Glasfibre geocomposite installed with 160/220 Pen grade bitumen	2011
Dundee Airport Runway	Dundee CC	Reflective cracking from underlying concrete slabs	100kn/m coated Glas fibre geocomposite installed with emulsion	
Heathrow Airport Taxiway 118/119	BAA	Flexible composite displaying reflective cracking from underlying Joints	50kn/m coated Glas fibre geocomposite installed with emulsion	2004
A167 Durham		Trial performance of steel mesh manufactured by TRC	Steel Mesh	April 1997
A631 Shepcote Lane, Tinsley	Sheffield CC	Dual carriageway upgrade to cope with increased traffic volume	Steel Mesh	
Moss Roads Lancashire	Lancashire. CC	Peat road suffering from high shrinkage, high compressibility and low shear strength	Steel Mesh	1991
A9 Daviot Scotland		Transverse cracking and rutting in parts	Steel Mesh	2001

APPENDIX E

INSTALLATION PHOTOGRAPHS

Filling excessive voids after planing the surface

Purpose built Applicator for installing Geosynthetics

Installing a Combination Grid onto Bond Coat

Installing a Glass Fibre Combination Grid

Protective layer of chippings applied onto a PMB sprayed on a Geosynthetic

Installation of a Polypropylene Grid

Combination Grid with Asphalt Overlay

Polypropylene Grid with Asphalt Overlay

Steel Mesh Installation

APPENDIX F

RSTA Geosynthetics & Steel Meshes Committee

Howard J. Cooke - Asphalt Reinforcement Services Ltd – Chairman

David Shercliff - Tencate Geosynthetics (UK) Ltd

Richard Carr – ABG Ltd

Ian Fraser – Tensar International Ltd

Tom Foster – Foster Contracting Ltd

Richard Bennett – Maccaferri Ltd

John Greenhalgh – Bekaert Ltd

Graham Thomson – Huesker Ltd

Howard Robinson - RSTA