GLASGRID®

technical manual

Advanced fiber glass technology for asphalt pavement overlays

SAINT-GOBAIN
TECHNICAL FABRICS

GLASGRID®
Technical Manual

Advanced fiber glass technology for asphalt pavement overlays

I. What is Reflective Cracking?

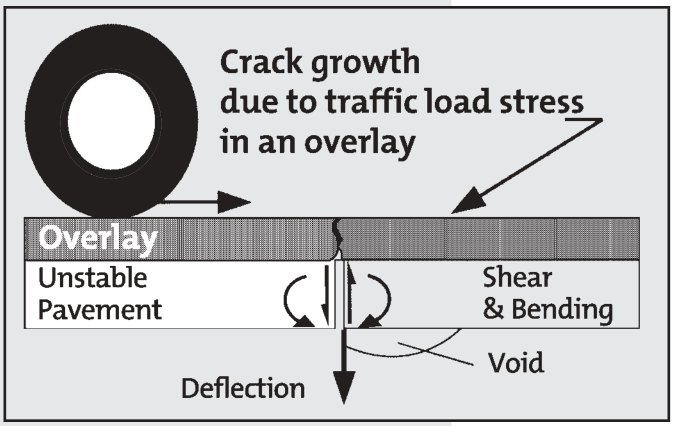
Many pavements, which are considered to be structurally sound after the construction of an overlay, prematurely exhibit a cracking pattern similar to that which existed in the underlying pavement. This propagation of an existing crack pattern, from discontinuities in the old pavement, into and through a new overlay is known as **reflective cracking.**

Reflective cracks destroy surface continuity, decrease structural strength, and allow water to enter sublayers. Thus, the problems that weakened the old pavement are extended up into the new overlay.

The cracking in the new overlay surface is due to the inability of the overlay to withstand shear and tensile stresses created by movements of the underlying pavement. This movement may be caused by either traffic loading (tire pressure) or by thermal loading (expansion and contraction).

Fatigue associated cracking occurs when shear and bending forces due to heavy traffic loading create stresses that exceed the fracture strength of the asphalt overlay. This is a structural stability problem.

Pavement instability is generally due to heavy loading, improper drainage, and time.



Unstable portland cement concrete (PCC) slabs are often identified by excessive movement or deflection during loading accompanied by the presence of water and fines pumping upward at the joint.

Instability in asphalt cement concrete (ACC) pavement is typically characterized by a series of closely spaced, multi-directional fatigue cracks. The distinctive pattern is often referred to as alligator cracking because it much resembles the appearance of the reptile's back.

Pavement rehabilitation strategies with flexible overlays require drainage improvements such as edge drains, surface sealing, structural improvements with full depth asphalt, patching, or subgrade reinforcement and sufficient structural overlay thickness to adequately support the design load. Load induced reflective cracks will inevitably appear in thin overlays that are under designed or in overlays placed on unsuitable base structures.

(continued...)

I. What is Reflective Cracking?

(continued)

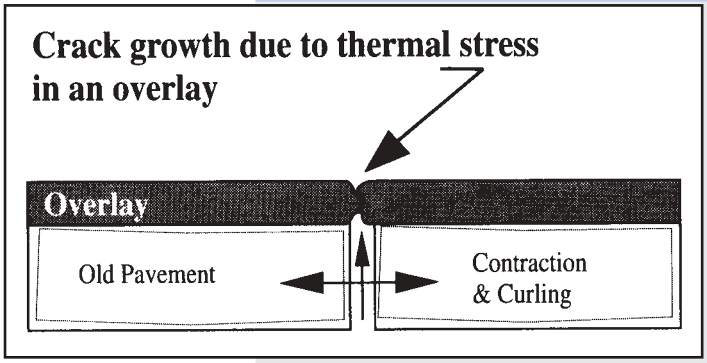
Structurally sound composite pavements are relatively resistant to load induced stresses. These traffic load stresses occur very rapidly and the stiffness, or fracture resistance, of both the asphalt overlay and base structure are very high.

Temperature associated cracking occurs when horizontal movement ⇄ due to thermal expansion, contraction, and curling of base pavement layers create tensile stresses in the overlay that exceed the strength of the asphalt.

Overlays placed on both ACC and PCC pavements are subject to thermal cracking. Thermal cracks usually appear in transverse and longitudinal directions.

Temperature cycling occurs over an extended period of time. The resultant horizontal stress loading occurs at a very slow rate, as compared to traffic loading stress rates. Under these very slow loading rates, the stiffness or fracture resiliency of the asphalt material is quite low, perhaps 1,000 to 10,000 times lower than the modulus exhibited by these same materials under traffic induced loading rates.

Flexible overlays placed on PCC pavements are particularly susceptible to thermal cracking at the slab joints. Thermal rates of expansion and contraction vary between materials such that any slab joint spacing almost always assures premature joint reflection.



TYPE OF REFLECTIVE CRACKS	TYPICAL PROBLEM
Transverse & longitudinal cracks at PCC slab joints	Thermal and Load associated
Transverse & longitudinal (non-joint) cracks	Thermal and Load associated
Lane widening joints, PCC/ACC interface	Thermal and Load associated
Block cracking, ACC pavements	Thermal and Material associated
Fatigue or Alligator cracks	Load associated
Utility cuts and pavement patches	Load associated

II. Testing Reflective Crack Properties of Overlays at Texas A&M

For many years, engineers have investigated the use of interlayers within the overlay to reduce the effects of reflective cracking. Interlayers can dampen stress, relieve strain, and provide tensile reinforcement to the asphalt.

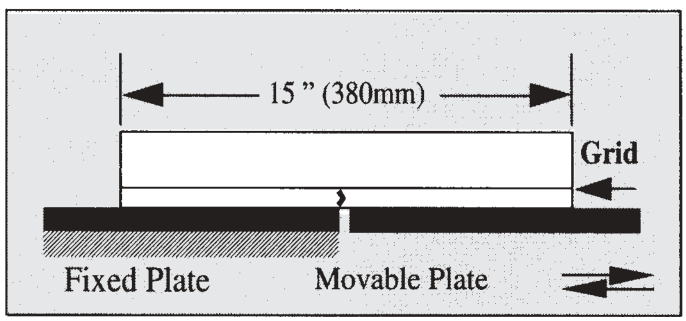
The conventional laboratory method of measuring an asphalt mixture's resistance to fracture is by flexural beam fatigue testing. Flexural loading simulates the action of traffic on the overlay. Unfortunately, it is difficult to predict performance of these same materials under age, hardening and thermal load conditions.

The only device which appears capable of simulating the effects of temperature cycling is the **Overlay Tester** in the Texas Transportation Institute (TTI) at Texas A&M University. The effects of many interlayer materials of varied strengths, configurations, tack coats, and embedment quantities have been evaluated at TTI.

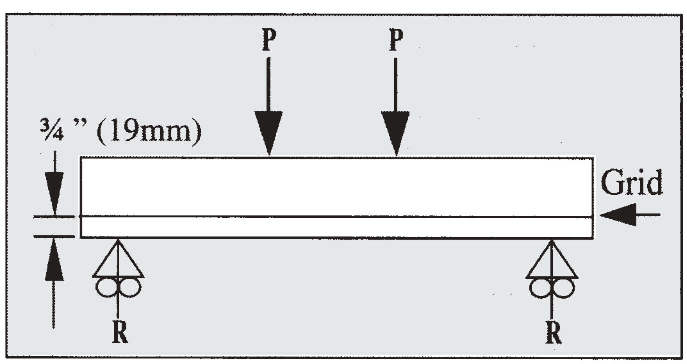
Beam fatigue testing is also conducted, distinguishing TTI as the first research institution able to predict the effects of both thermal and flexural loading. Separately testing each mode of fracture permits a more careful investigation of optimum interlayer reinforcement properties and positions within the overlay. TTI has adopted this approach because these tests more clearly isolate the contribution of the interlayer to reduce or eliminate the rate of crack growth through an overlay. This leads directly to more effective rules, guidelines, and specification limits on the use of interlayers.

Since 1986 extensive "overlay" and "beam fatigue" testing has been completed at TTI on asphalt beams reinforced with GlasGrid®.

Schematic Diagram of the Overlay Test



Schematic Diagram of the Beam Fatigue Test



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II. Testing Reflective Crack Properties of Overlays at Texas A&M

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Beam Fatigue Test Results: Beam fatigue test data is typically plotted on a logarithmic scale and the equation of the line through the data points is:

$$N_f = K_1 \left(\frac{1}{\mathcal{E}}\right)^{K_2}$$

where,

N_f = the number of load cycles to failure

$\mathcal{E}$ = the extreme fiber tensile strain

K_1 = the fatigue coefficient

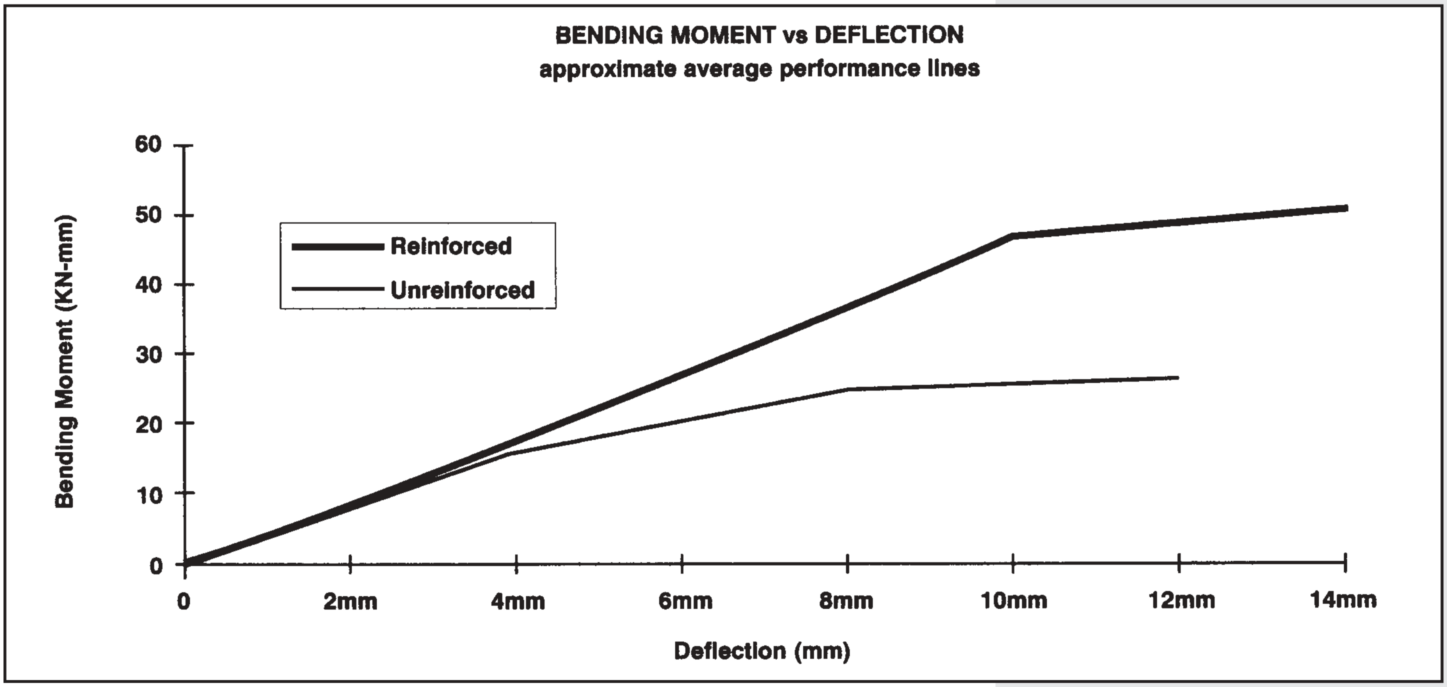
K_2 = the fatigue exponent

The values of K_1 and K_2 for the reinforced samples are different than those of the reference samples indicating a distinguishable effect on the fatigue properties of the asphaltic concrete beam. The slope of the fatigue line, K is smaller for the 75mm (3") beams reinforced with GlasGrid (3.77) than for the unreinforced 75mm (3") beam (5.55) and the unreinforced 100mm (4") beam (3.91). **This means that the reinforced 75mm (3") beam is more resistant against fracture than is the unreinforced beam with an additional 25mm (1") of thickness.**

Sample	K1	K2
75mm (3") w / Grid	5.243×10^{-4}	3.77
100mm (4") w /o Grid	4.711×10^{-4}	3.91
75mm (3") w /o Grid	2.465×10^{-4}	5.55

Additional flexural beam fatigue testing conducted for Saint-Gobain Technical Fabrics at an independent laboratory under the direction of Dr. Emery reveals the following moment-deflection diagram.

The diagram clearly shows that GlasGrid reinforced specimens resist up to 2 times more bending load at rupture than unreinforced control specimens at the same deflection.



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II. Testing Reflective Crack Properties of Overlays at Texas A&M

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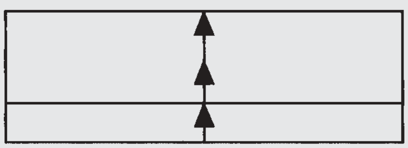
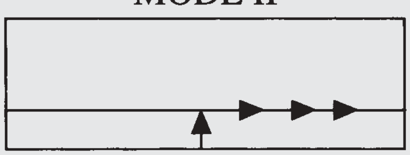
Overlay Test Results: Three distinct modes of failure are observed in overlay tests,

MODE I



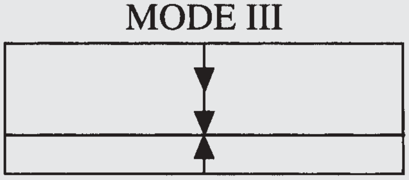
Mode I - Crack propagates from bottom to top

MODE II



Mode II - Crack propagates to bottom of reinforcement and then is redirected horizontally

MODE III



Mode III - Crack propagates up to reinforcement, then starts again from top of sample and propagates downward

Testing of the first generation GlasGrid reinforced specimens, which did not have an adhesive and had lower tensile strength, indicate failure almost exclusively by Mode I crack propagation. The current GlasGrid product produces exclusively a Mode II failure (see Page 11). Mode I and Mode III occur when the material in the overlay acts as a "strain-relieving" layer such as paving fabrics and SAMI's.

Mode I data is analyzed by the basic equation of fracture mechanics, Paris' Law:

$$dc/dN = A\,(\Delta K)^n$$

where,

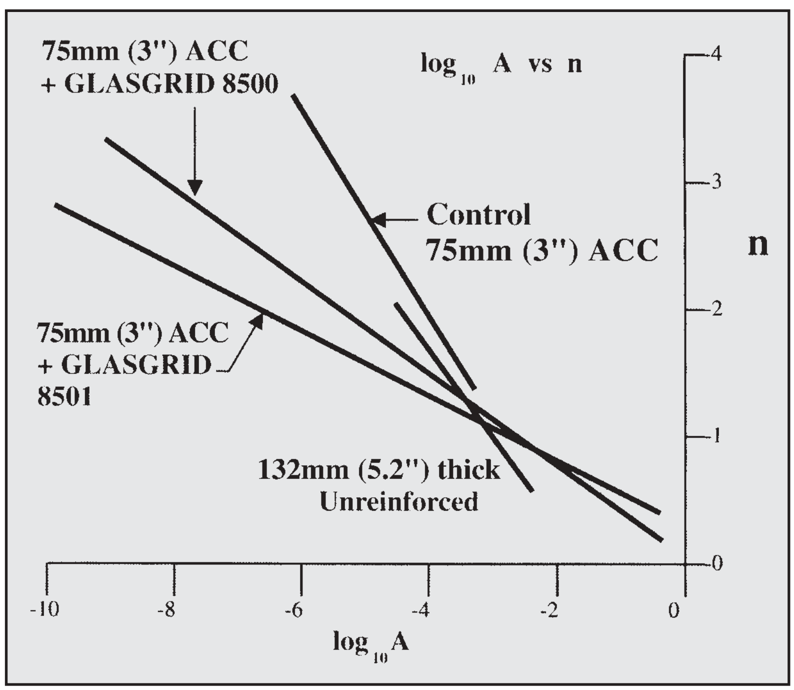
dc/dN = rate of crack growth per load cycle

ΔK = stress intensity factor change during loading

A, n = fracture material properties

The linear relationship between log A and n is plotted to the right and is described by the equation: $n = a - b \log_{10} A$. This counter clockwise rotation of $\log_{10} A$ vs n line represents a great increase in crack resistance.

GlasGrid reinforced samples clearly outperformed control samples with over 55mm (2.2") of additional thickness.



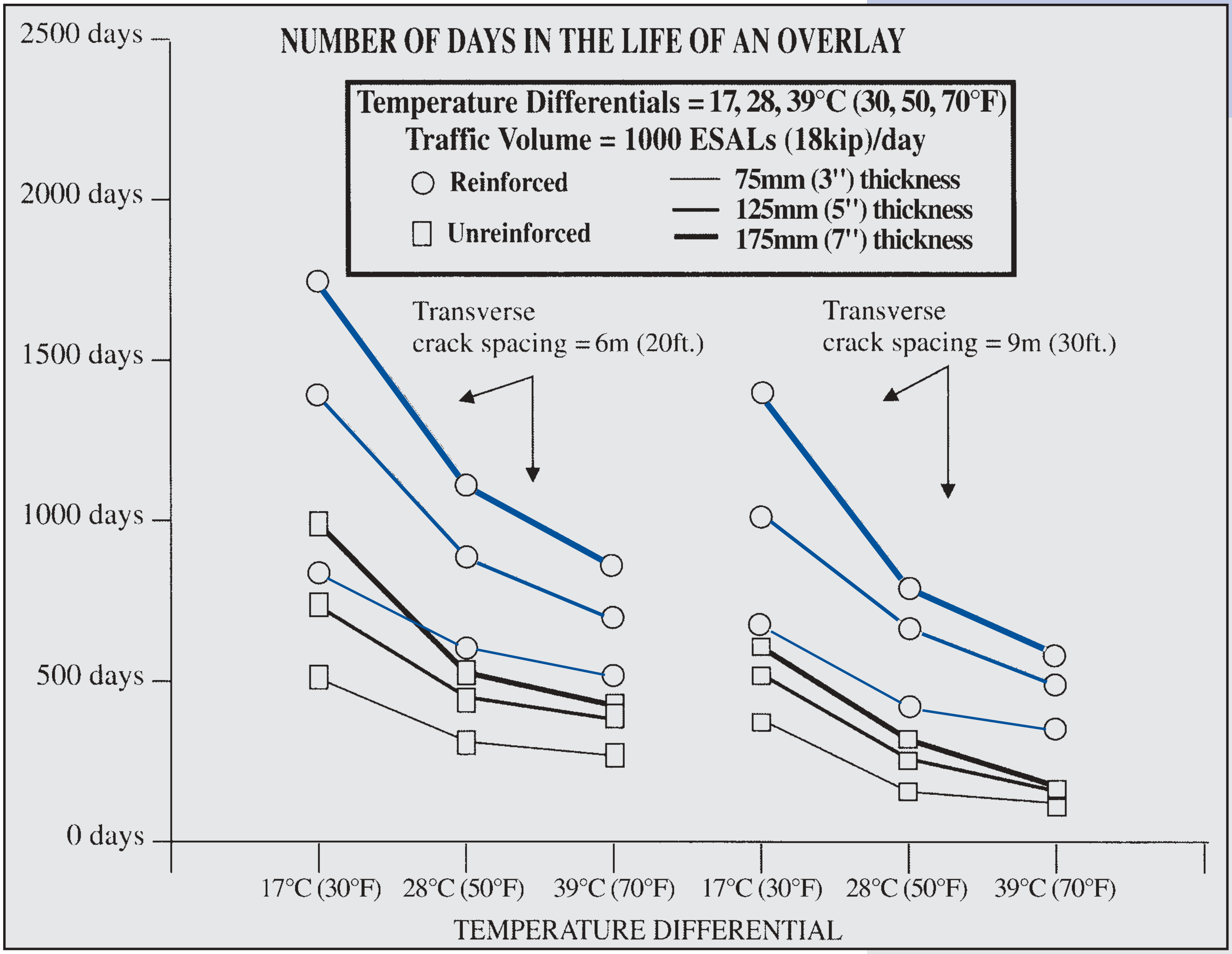
GlasGrid with 75mm (3") of ACC outperforms 132mm (5.2") of unreinforced ACC

(continued...)

II. Testing Reflective Crack Properties of Overlays at Texas A&M
(continued)

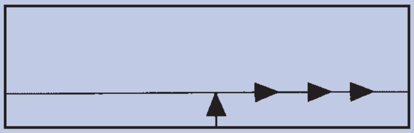
"SIMPLE," a computer program developed at the Texas Transportation Institute, provides a comprehensive mechanistic method of computing the reflective cracking life of an overlay. It remains the first and only program capable of predicting the combined influence of traffic and thermal stresses.

Fracture properties obtained in the TTI research study have been input into "SIMPLE" along with traffic data, temperature data, existing pavement data, and overlay data in order to determine the design life of reinforced and unreinforced overlays.



The resulting outputs along with field observations from hundreds of projects worldwide have been used to establish guidelines and limitations for the use of GlasGrid.

III. GlasGrid Performance from Texas A&M University

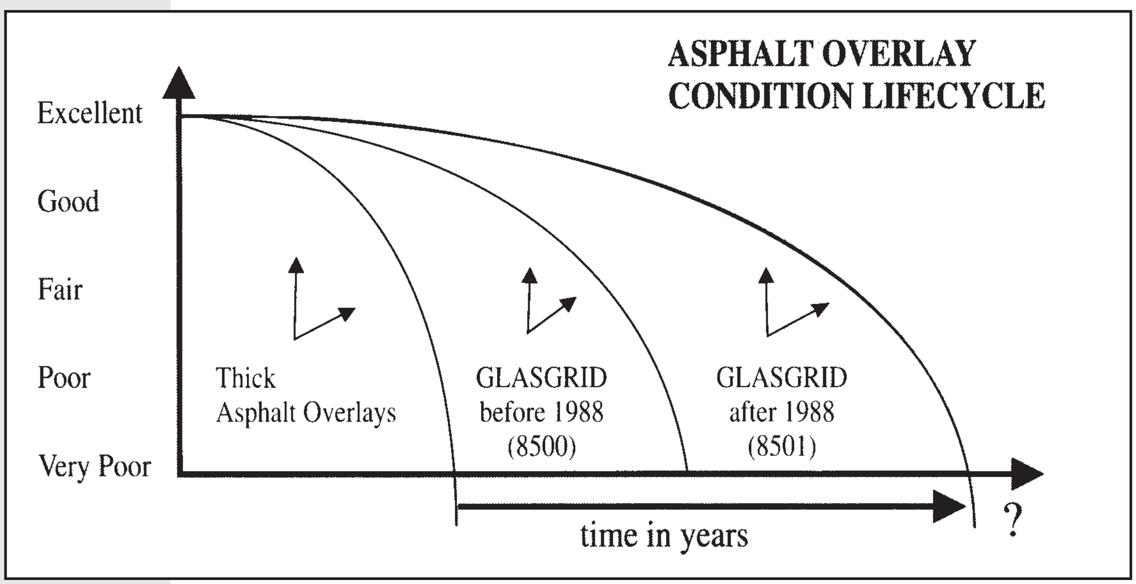


Mode II - Crack propagates to bottom of reinforcement and then is redirected horizontally.

Finally, in 1988 Saint-Gobain Technical Fabrics had produced a new fiber glass grid structure that was found to provide sufficient reinforcing to the overlay above and strain-relief beneath the grid to actually turn the crack horizontally, and not permit it to propagate vertically upward through to the top of the sample.

This new grid has a self-adhesive glue with increased tensile strengths. Mode II crack propagation occurs when the material in the overlay "reinforces" the overlay. This can only occur if the material has a higher modulus and sufficient cross-sectional area to substantially strengthen the overlay. "There are no methods to predict the reflective cracking life of an overlay when this happens, but there is suspicion that it could be indefinite. Any deterioration will be due to another cause", as stated by Dr. Lytton from Texas A&M University.

Overlay subjected to large temperature changes exhibit reflective cracking. Based on the research conducted at the Texas Transportation Institute, it can be concluded that GlasGrid can prevent this phenomena from occurring and offer a substantial increase to crack resistance caused by traffic load induced stresses.



History has shown that three major influences dictate the performance of asphalt reinforcement: Material Composition, Product Geometry, and Jobsite Constructability.

Material Composition

As with any product of quality, it is essential to begin with the proper raw materials. Asphalt reinforcement must provide increased tensile strength at a very low deformation. It must be compatible with the asphalt to provide a strong internal bond within the composite. It must be thermally stable and physically durable to withstand the rigors of the paving operation. And finally, for long term performance, it must exhibit no creep deformation or chemical breakdown over time.

Product Geometry

The geometric configuration of an interlayer will greatly affect its reinforcement capability. The cross-sectional area must be sufficient so that it will redirect tensile stresses. The width of the product must exceed the limits of the redirected stress energy. Finally, the opening (windows) in the mesh must be such that optimum shear adhesion is achieved while promoting aggregate interlock and confinement.

Jobsite Constructability

Practical application of any reinforcement requires the ability to adapt to any paving operation. Placement must be quick and easy, and the product must remain secure during paving.

GlasGrid is composed of high modulus fiber glass strands coated with modified polymer and adhesive backing.

IV. Engineer Checklist for Specifying Overlay Reinforcement

Why Does GlasGrid Reinforcement Retard Reflective Cracking?

HIGH TENSILE STRENGTH

LOW ELONGATION

NO LONG-TERM CREEP

CROSS-SECTIONAL AREA

ASPHALT COMPATIBILITY

THERMAL STABILITY

CHEMICAL STABILITY

PHYSICAL DURABILITY

WIDTH

SHEAR ADHESION

INTERLOCK & CONFINEMENT

QUICK INSTALLATION

IV. Engineer Checklist for Specifying Overlay Reinforcement

(continued)

HIGH TENSILE STRENGTH

High modulus, E, fiber glass exhibits a tremendous strength to weight ratio and is pound for pound stronger than steel. With a modulus ratio up to 20:1 over asphalt concrete (20°C or 68°F), GlasGrid clearly provides the stiffness required to redirect crack energy.

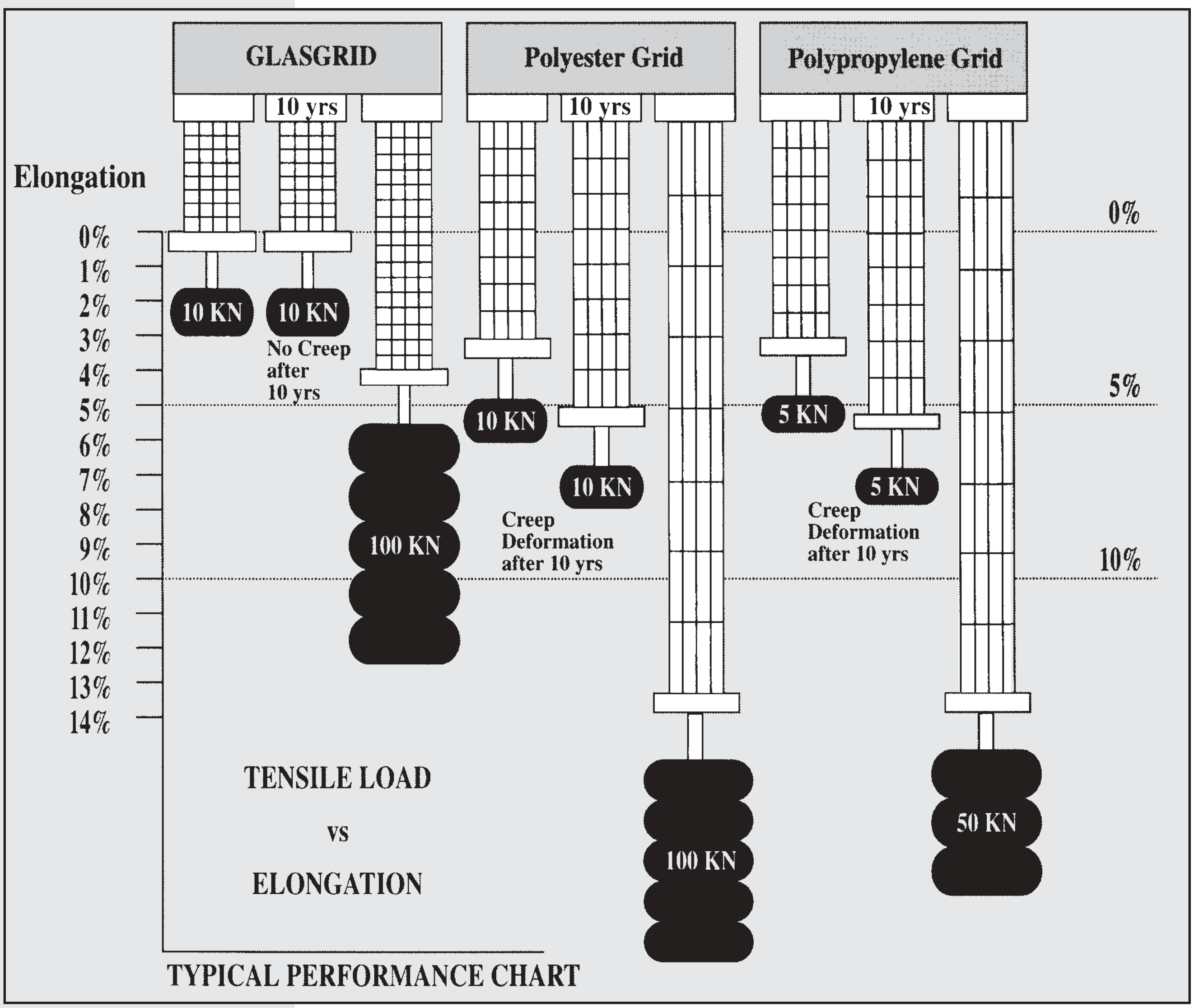
LOW ELONGATION

The stress-strain diagram for glass is virtually a straight line of nearly vertical slope. This indicates that the material is very stiff and resists deformation. GlasGrid exhibits less than 5% elongation at break.

NO LONG-TERM CREEP

Many reinforcement materials that appear to be initially stable, exhibit creep deformation due to constant loading over long periods of time. Fiber glass exhibits no creep. This assures long term performance.

TYPICAL ASPHALT PAVEMENT GRIDS CREEP CHARACTERISTICS



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IV. Engineer Checklist for Specifying Overlay Reinforcement

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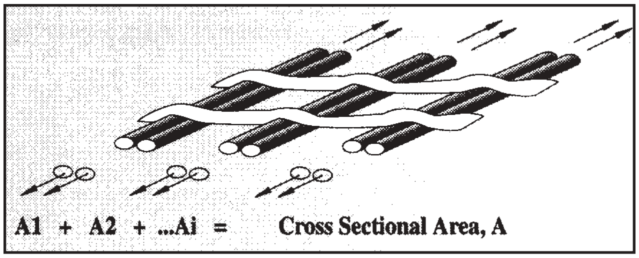
CROSS SECTIONAL AREA

Sufficient cross sectional "Area, A" multiplied by the "Modulus, E" of the material (= AE) is required to redirect crack energy. The research conducted at Texas A&M shows GlasGrid meets this requirement.



ASPHALT COMPATIBILITY

The specially formulated polymer coating was designed to deliver high asphalt compatibility. Each fiber is completely coated to insure no slippage within the composite asphalt.

THERMAL STABILITY

The melting point of fiber glass is 1000°C (1800°F). This insures stability when subjected to the excessive heat of a paving operation.

CHEMICAL STABILITY

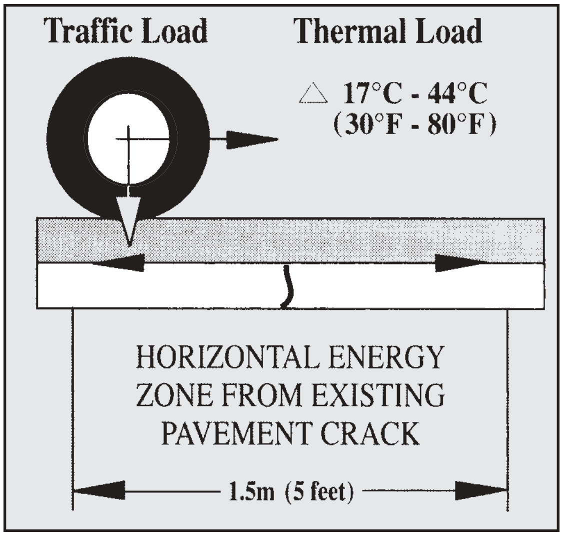
The specially formulated polymer coating was designed to provide protection against a wide range of chemical attack.

PHYSICAL DURABILITY

The specially formulated polymer coating provides protection from physical abrasion. Additionally, coated fiber glass is resistant to biological attack, UV light, and weather.

WIDTH

Field trials indicate that the reflective crack energy of a redirected horizontal crack can travel up to 0.6m (2 feet) beyond its point of origin. 1.5m (five foot) wide patch reinforcement (style #8502) helps insure complete dissipation on either side of the crack. Lesser widths have shown horizontal propagation to turn vertically upward at the reinforcement limits resulting in a lesser crack on each side of the interlayer.



SHEAR ADHESION

The specially formulated polymer coating provides GlasGrid reinforced overlays with sufficient adhesion to maintain a good bond between asphalt concrete overlays.

(continued...)

IV. Engineer Checklist for Specifying Overlay Reinforcement

(continued)

INTERLOCK & CONFINEMENT

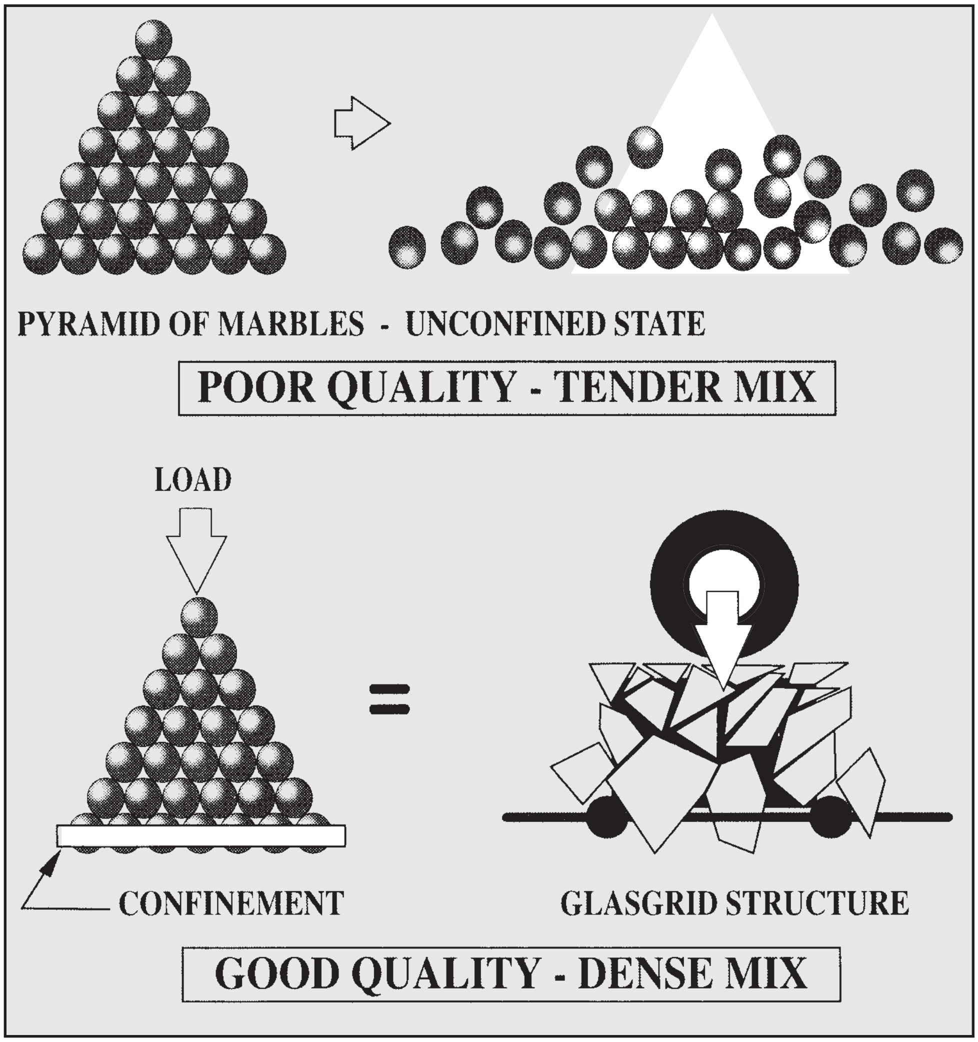
Asphalt concrete gains its compressive strength through compaction. The mix aggregate is specifically selected to provide interlock and confinement within the load bearing stone structure, and asphalt cement (AC) is the glue that holds the particles together.

The quality of both the aggregate and the AC will determine the quality of the final pavement structure.

As particles strike through the GlasGrid structure, they become mechanically interlocked within the composite system. This confinement zone impedes particle movement. Asphalt mixtures can achieve better compaction, greater bearing capacity, and increased load transfer with less deformation. Testing indicates that the 12.5mm x 12.5mm (1/2" x 1/2") window is optimum for most surface mixes.

EASY INSTALLATION

GlasGrid with its unique adhesive allows quick and easy installation. The product can be rolled out mechanically with SGTF's special placement tractor or manually from the back of a pick up truck. Placement procedures are outlined in detail in the GlasGrid *"Installation Guide"*.



GlasGrid Improves Interlock and Confinement

GENERAL DESIGN CONSIDERATIONS:

V. GlasGrid Reinforced Overlay Design Guidelines & Limitations

Site Selection

Care must be taken when selecting a site for the potential use of GlasGrid. The existing pavement section must show no signs of pumping, excessive movement, or structural instability. To maximize the benefit of GlasGrid, pavements must be structurally sound. If a pavement is structurally unstable, the Engineer should design to first address the structural problem, then the reflective cracking problem.

Pavement Evaluation

Field evaluation should include a visual distress survey in accordance with a Pavement Condition Index (PCI) methodology and deflection testing, such as a falling weight deflectometer (FWD). This data should be used to determine the effective modulus of the existing pavement section. Slab replacement, mud jacking, full depth asphalt replacement, and pot hole repairs shall be made prior to the placement of the overlay, as determined by an Engineer.

Crack Sealing

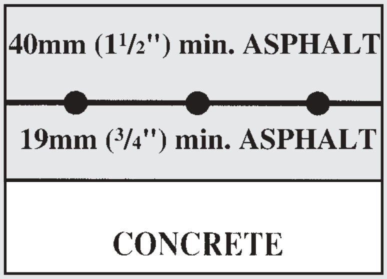
All existing pavement cracks should be sealed by conventional methods. Cracks greater than 6mm (1/4") should be filled with a suitable crack filler.

Levelling Course

GlasGrid performs best on a levelling course and must be placed on a smooth, level, asphaltic surface. A minimum 19mm (3/4") levelling course of asphalt must be placed on concrete surfaces without an existing overlay. Crack areas exhibiting excessive surface irregularities such as faulting shall also be levelled. Slab joints exhibiting upward tenting must be saw cut to relieve pressure prior to levelling.

Minimum Depth of Overlay

GlasGrid requires a minimum overlay thickness of 40mm (1.5"). The procedures outlined in the GlasGrid *"Installation Procedures"* shall be strictly followed.



Tack Coats are optional with GlasGrid. Local conditions or specifications may require a tack coat to be used.

GlasGrid is suitable for most pavement sections. Pavements with a high potential for slippage must be carefully evaluated to determine suitability.

Always remember ... "If there is poor load transfer across the crack, no reinforcement will help!", as stated by Dr. Lytton at Texas A&M University.

VI. Special Contract Provisions for GlasGrid

1. DESCRIPTION:

Work shall consist of furnishing and placing a high strength open fiber glass mesh grid between pavement layers for the purpose of incorporating a reinforcing grid within the pavement structures. The specification guide is applicable to high strength modulus reinforcing grids for full width coverage of the pavement.

2. MATERIAL SPECIFICATION: GlasGrid 8501

The material with this specification shall be constructed of fiber glass yarns knitted in a stable construction that conforms to the following properties when tested by the appropriate test method.

Tensile Strength	kN/m	lb./in
Component strand strengths	100	560
Test Method G.R.I. GG 1-87 or ASTM D 6637		
Elongation at Break	Percent	Percent
Maximum	5	5
Test Method G.R.I. GG 1-87 or ASTM D 6637		
Melting Point	Celsius	Fahrenheit
Minimum	218	425
Test Method ASTM D 276		
Mass/Unit Area	g/m^2	oz/yd^2
Test Method D 5261-92	370	11

All values represent certifiable average minimum roll values in the weakest principal direction of the grid. Manufacturer must supply test data prior to the start of grid placement to the Engineer. Data must be signed by the quality assurance principal at the manufacturing facilities and be representative of all product on the project.

3. STORAGE:

Reinforcement Grid must be stored as per manufacturer recommendations in a dry covered condition free from dust, dirt and moisture.

4. PAVEMENT PREPARATION:

Surface must be prepared as a clean, dry, even surface with pavement cracks sealed.

a. Cracks between 3mm (1/8") and 6mm (1/4") should be filled with a suitable crack filler. Wider cracked surfaces need to be addressed with a method that provides a level surface. Any holes need to be filled with hot mix. Uneven surfaces and extensive cracking shall use a levelling course preferably with a dense graded mix of a minimum average thickness of 19mm (3/4").

b. On milled surfaces the following surface treatment shall be carried out:

1. A minimum 19mm (3/4") asphalt concrete levelling course shall be applied to the milled surface prior to placing the glass mesh.
2. The surface temperature before laying the grid shall be between 5°C (40°F) and 60°C (140°F).

(continued...)

c. Prior to placing grid, the existing pavement shall be cleaned and provide significant adhesion to the grid to the satisfaction of the Engineer. Pavement shall be cleaned by a mechanical device by sweeping or vacuuming and be free of oil, vegetation, sand, dirt, water, gravel, and other debris.

5. CONSTRUCTION

a. Tack coats are optional. If local conditions require a tack coat to be used, the grid manufacturer shall recommend a tack coat rate that will provide proper adhesion.

b. The grid shall be laid out by mechanical means or by hand under sufficient tension to eliminate ripples. Should ripples occur, these must be removed by pulling the grid tight or in extreme cases (on tight radii), by cutting and laying flat.

c. Transverse joints must be lapped in the direction of the paver 75 - 150mm (3" - 6"). Longitudinal joints must be 25 - 50mm (1" - 2") overlapped.

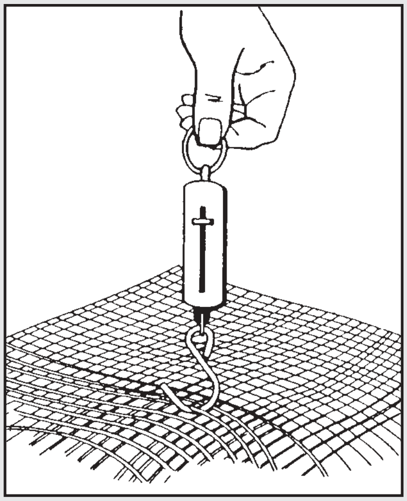
d. The surface of the grid shall be rolled with a rubber coated roller, or pneumatic tire roller, to activate the adhesive. Tires must be clean to avoid pick up of the grid.

e. Construction and emergency traffic may run on grid after being rolled. However, it must be ensured that damage is not caused to the grid by vehicles turning or braking etc., and that the mesh must be kept clean of mud, dust and other debris. Damaged sections shall be removed and patched, taking care to completely cover the damaged area.

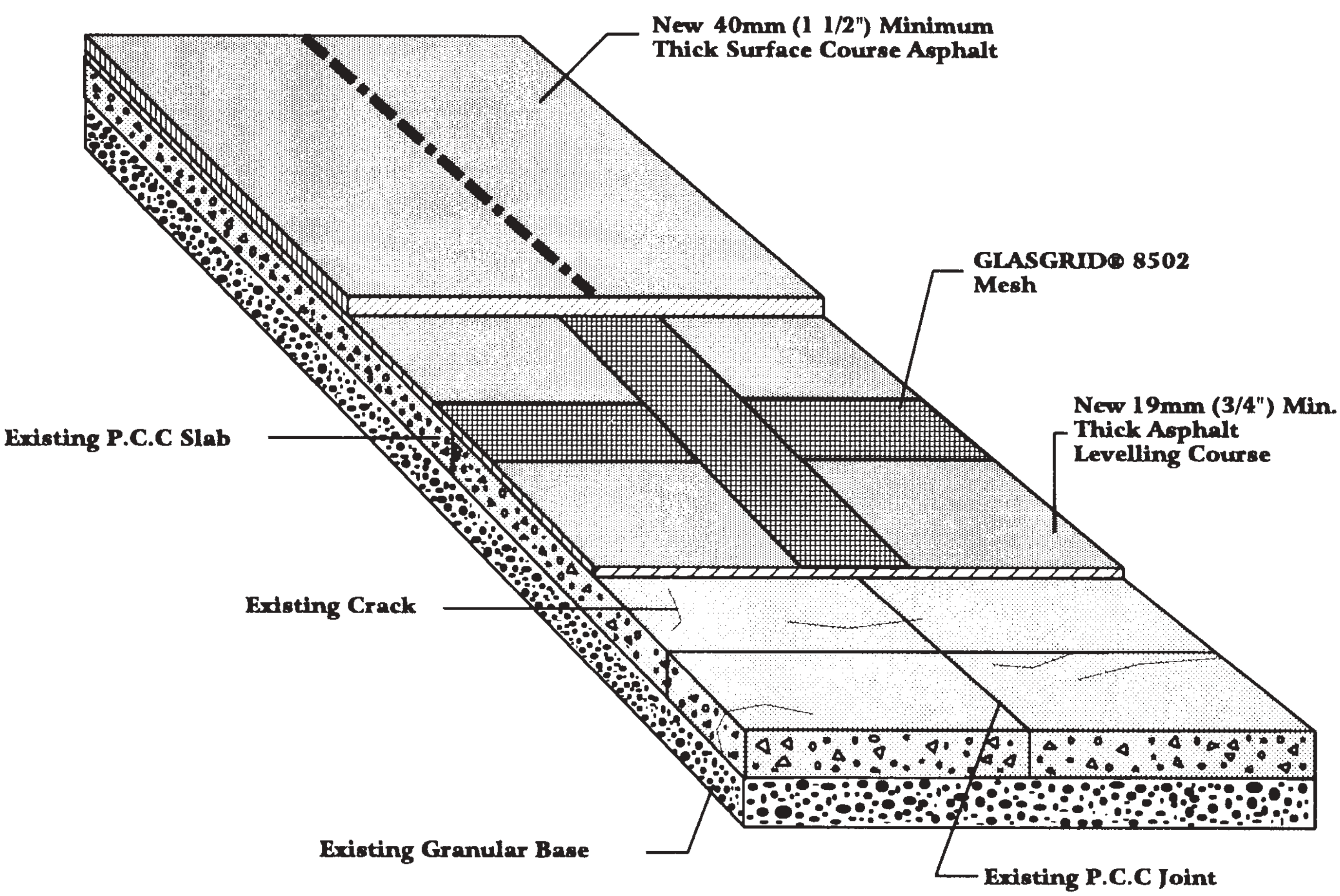
f. The contract price per square yard/square meter for the reinforcing grid shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals involved in furnishing and placing the grid completely in place, as shown on the plans required by these special provisions and as directed by the Engineer.

6. TESTS FOR PROPER ADHESION

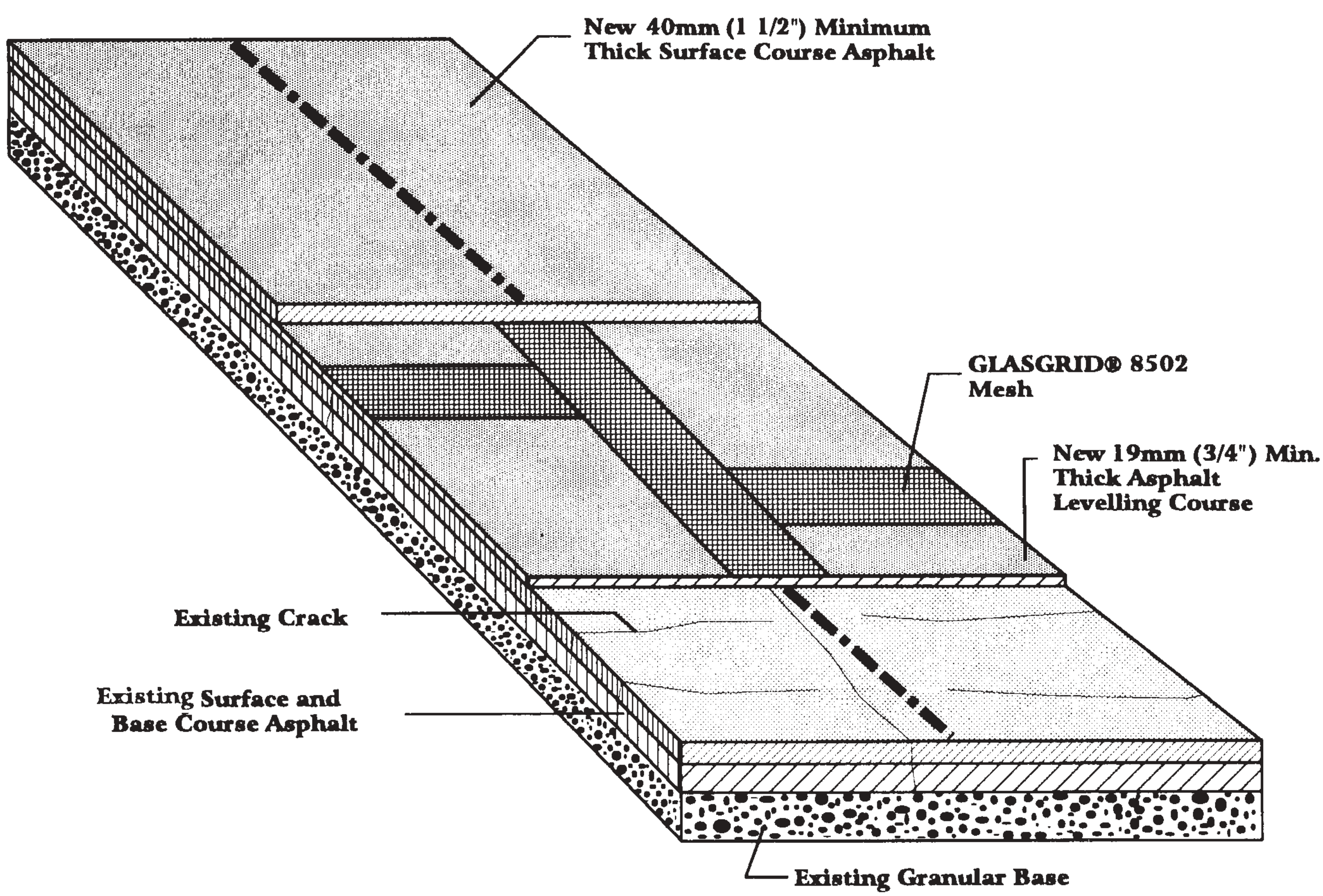
1. Cut approx. 1m^2 (1 sq. yd.) of grid.
2. Place on area to be paved.
3. Activate self-adhesive glue by rolling with a rubber tired roller or by walking on the sample.
4. Insert hook of spring balance under center of grid piece.
5. Pull upwards until grid starts to pull from the surface.
6. Record results in kg. or lb.
7. If approx. 5 kg (11 lbs) or more, OK to pave. Stop immediately if grid moves or ripples. IF LESS THAN 5 KG (11 LBS) - DO NOT PAVE DUE TO POOR ADHESION.



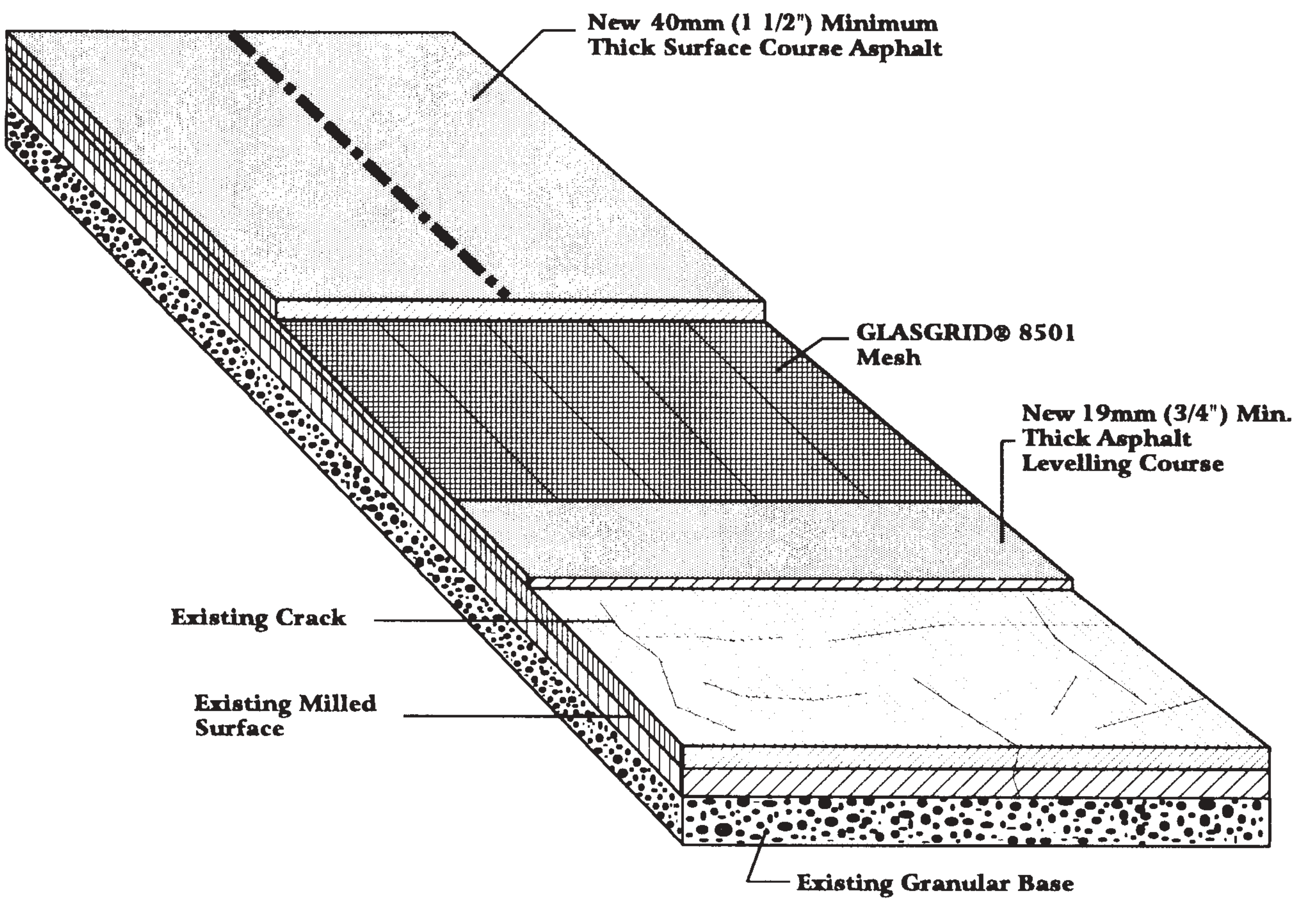
GlasGrid 8502 Detailed Repair System
Portland Cement Concrete Pavement



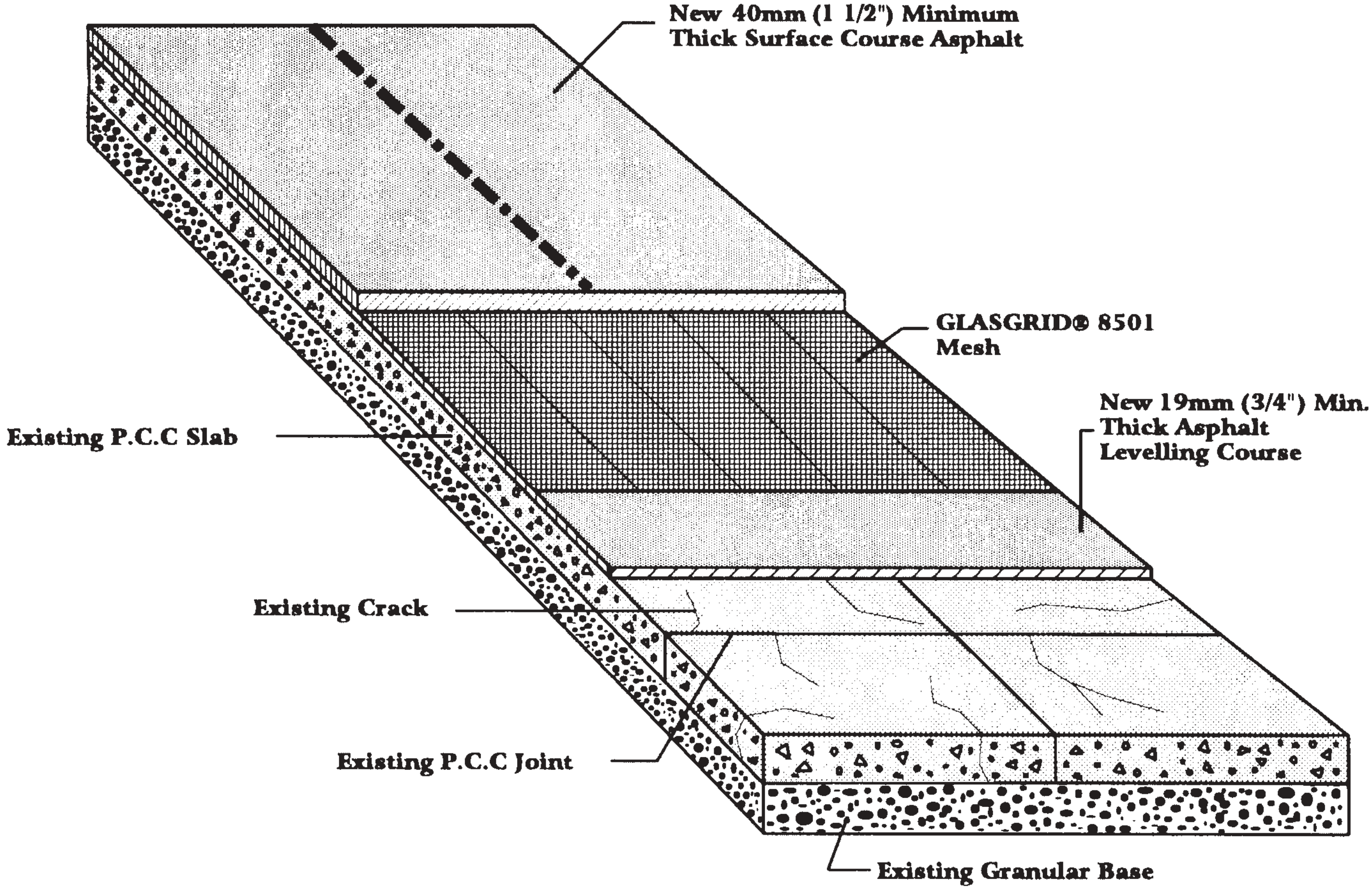
GlasGrid 8502 Detailed Repair System
Asphalt Concrete Pavement



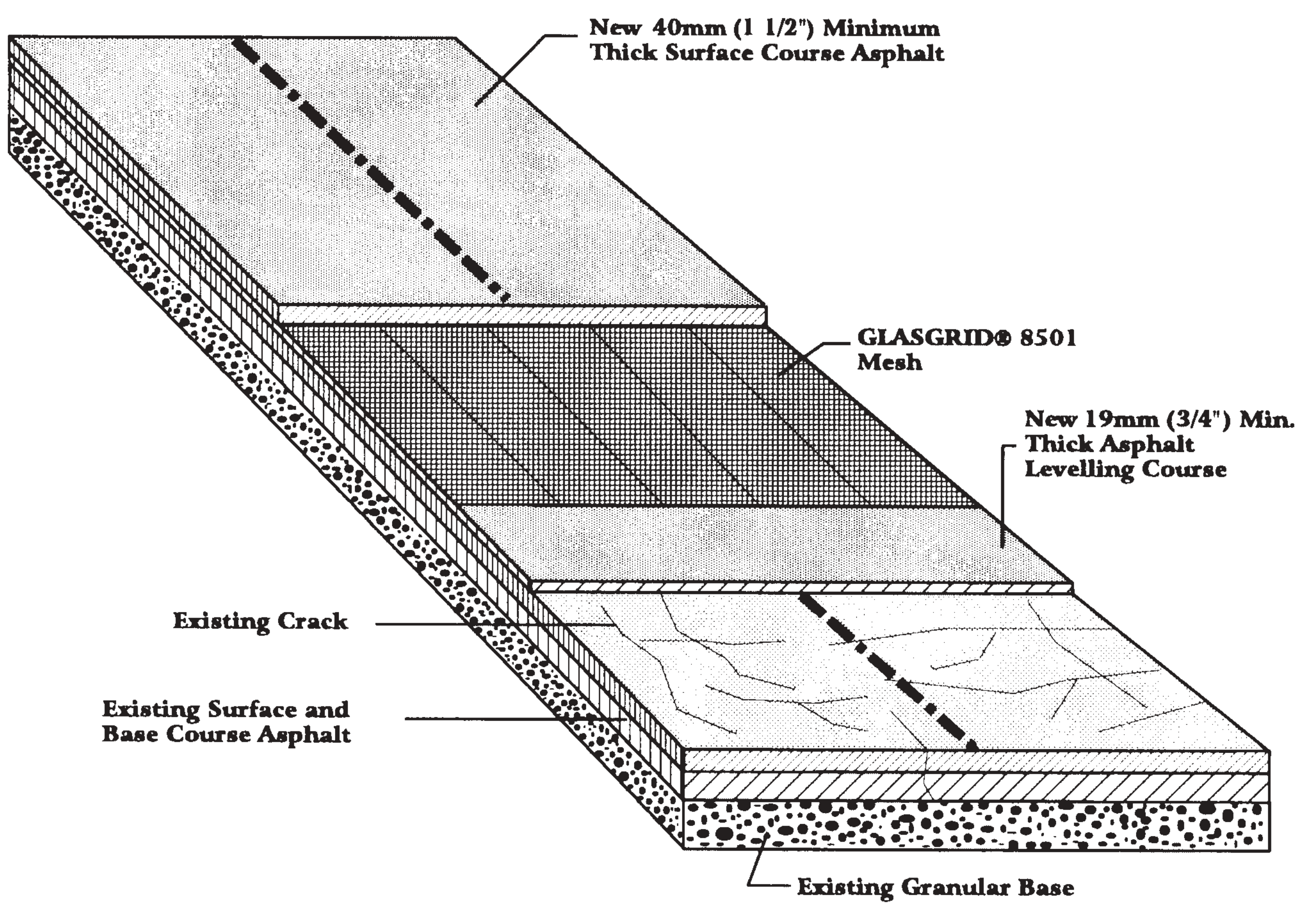
GlasGrid 8501 Complete Road System
Milled Pavement



GlasGrid 8501 Complete Road System Portland Cement Concrete Pavement



GlasGrid 8501
Complete Road System Asphalt Concrete Pavement



Saint-Gobain Technical Fabrics

Email: glasgrid@saint-gobain.com

Websites: www.sgtf.com
www.glasgrid.com

GlasGrid is manufactured at an ISO 9002-1994 registered facility of Saint-Gobain Technical Fabrics

SAINT-GOBAIN
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