Evaluation of Fabrics, Fibers and Grids in Overlays

Texas Transportation Institute

1987

EVALUATION OF FABRICS, FIBERS AND GRIDS IN OVERLAYS

Joe W. Button and Robert L. Lytton

ABSTRACT

A comprehensive assessment of engineering fabrics, synthetic fibers and polymeric and fiberglass grids applied to reduce reflection cracking in asphalt concrete overlays has been conducted. The experimental program included laboratory testing to evaluate stability as well as tensile, fatigue, creep and shear properties of asphalt mixtures containing these products. Computer programs were used to predict pavement service life under various conditions of traffic, subgrade and climate. Finite element theory and fracture mechanics were employed in the analysis. Pavement construction with fabrics, fibers and grids was observed and performance was evaluated.

Fabrics, fibers and grids have the capacity to delay cracking in asphalt concrete overlays; however, proper construction techniques are imperative to achieve improvements in performance. Fabrics must be applied with the proper quantity of asphalt tack and with an adequate thickness of a nonporous overlay mixture. Fibers in hot mix require additional asphalt as well as additional compactive effort to attain adequate density. Grids perform best when applied in conjunction with a conventional seal coat.

INTRODUCTION

Proper evaluation of a new highway material requires the application of appropriate mechanistic analyses to project the useful life, a carefully planned laboratory test program, and observation of field installations. A complete program has been accomplished at the Texas Transportation Institute (TTI) for a variety of engineering fabrics, polymeric and fiberglass grids, and chopped synthetic fibers used in overlays. The result is a comprehensive assessment of the value of these materials as inclusions to prolong the service life of overlays.

Laboratory testing involved beam fatigue, direct and indirect tension tests of laboratory samples and pavement cores, special "interface shear" tests for the fabrics, repeated load creep and permanent deformation tests, and TTI's "overlay test" which simulates the stresses and displacements imposed on an overlay by thermal variations. The laboratory tests also included the more common tests of stability, moisture susceptibility, and others.

Mechanistic analyses included predictions of overlay life with the FHWA VESYS program, the Shell method and TTI's overlay reflection cracking program SIMPLE. The latter program uses the principles of fracture mechanics, and employs the bending and thermal fracture properties derived from the analysis of the beam fatigue and overlay test results, to predict the reflection cracking life of an overlay due to both traffic and thermal stresses.

Field observations of test sections using the fabrics, grids and fibers include notes on the construction of overlays with these new materials, the traffic and climatic conditions to which they were subjected, the unusual problems encountered in their placement and performance, and their resistance to reflection cracking.

It must be recognized at the outset that any fabric or grid will service one of two mutually exclusive purposes in overlays: reinforcing or strain relieving. In order to reinforce an overlay, a fabric or grid must have a modulus that is substantially (more than 5 times) larger than that of the surrounding asphaltic concrete. If such is the case, and the fabric or grid is overlaid with a layer of sufficient thickness, reflection cracks will be turned to travel horizontally below the fabric or grid. In strain relieving fabric or grid layers, the cracking reflects through the overlay directly without breaking the compliant fabric or grid but is delayed in its growth by the intermediate layer. The effectiveness of such strain-relieving fabric or grid layers is to be found in the amount of asphalt tack coat that can be applied without causing bleeding or flushing of the pavement surface. The distinction between "reinforcing" and "strain relieving" is a crucial one since the genuinely reinforced overlay has a better chance to retard reflection cracking for a considerable period of time. Strain-relieving fabrics or grids can also delay reflection cracking provided that they are coupled with an adequate overlay and a sufficient amount of strain relieving bitumen. Once the crack penetrates through the overlay, the fabric or grid will hold the cracks together to reduce spalling and leakage of water.

Reflection cracking occurs as a combination of three fracture mechanisms: bending, shear, and thermal contraction. Bending ceases to operate as a fracturing mechanism once the overlay is less than half of the total thickness of the asphaltic layers. All of the fabrics and fibers are much more effective against horizontal movement (bending and thermal contraction) than against a shearing displacement. They are also more effective when the horizontal movements are small, as in the case of pavements with alligator cracks or closely spaced thermal and block cracking. No overlay, either reinforced or strain-relieved, may be expected to work well as an overlay of jointed concrete pavement with poor load transfer across the joints or cracks.

Synthetic fibers present a different approach to extending the life of overlays. They re-distribute the strain in an overlay immediately above a crack. Instead of a single crack reflecting upward, the fibers cause the crack to branch out, expending the energy in driving several cracks upward through the overlay at a slower rate. Fibers require somewhat more asphalt and as a result of the greater film thickness in the mix, more resistance to moisture effects can be expected. Fibers are more effective against bending and thermal contraction displacements than against shear displacements.

This paper presents the mechanistic basis of the analysis of fracture of overlays for both the strain-relieving and reinforcing layers and also presents summaries of the field observations of reflection cracking and other distress in the many overlays that have been constructed and observed in the last ten years. The conclusion of this paper summarizes our experience to the present time with fabrics, grids, and fibers in the laboratory, in theory, and in the field.

MATERIALS

Asphalt Concrete Mixture

The asphalt concrete mixture selected for use in these laboratory studies consisted of a blend of river gravel, sand and limestone crusher fines, with an AC-20 binder. This mixture was purposely chosen because it exhibits relatively low stability and poor tensile properties. A mixture with these characteristics should allow improvements by materials such as fibers, fabrics and grids.

Fibers

Ten different types of fibers with a wide variety of physical properties were used in the study (1). Polyester and polypropylene fibers are by far the most widely used in paving applications. Kevlar is composed of aramid which has a modulus (9×10^6 psi) near that of glass (10×10^6 psi). The modulus of the other fiber materials ranges from 500,000 to 1,000,000.

Fabrics

About 20 fabrics manufactured by different processes and from different materials were evaluated (2-5). Some were commercially available products while others were specially prepared experimental fabrics. They included DuPont Typar and Reepav, Monsanto Bidim, Phillips Petromat, Crown-Zellerbach FiberTex, Owens-Corning Roadglas, Mirafi 140, 900X, woven tapes and several woven/nonwoven composite products, and a woven fabric precoated with asphalt. Two or three weights (4 to 8 ounces per square yard) of several fabrics were tested. Optimum asphalt content was determined using a special test as that amount required to completely saturate the fabric. Low and high asphalt contents were one half and twice the optimum amount, respectively.

Grids

Two types of reinforcing grids were evaluated: one of a polypropylene material which has been punched and drawn into a grid 2 inches x 2.8 inches (Tensar) and the other grid from Bay Mills, Ltd. made of fiberglass strands woven into a rectangular pattern (0.85 inches x 0.85 inches) and tied at the intersections. Various cross-sectional areas of the fiberglass grids were tested.

LABORATORY TEST RESULTS

Mixture Stability with Fibers

Tests were conducted on asphalt concrete mixtures containing nine different types of fibers at one to three concentrations. It appears that any of the standard mix design methods can be used satisfactorily with fiberized mixtures. All the specimens in this test program (1) were prepared using the Texas gyratory compactor.

When fibers are introduced into a paving mixture, additional asphalt is necessary to coat the fibers. (This is similar to the addition of very fine aggregate.) The proper quantity of asphalt for consistent coating of all particles is different not only for different concentrations but also for different types of fibers. This is likely due to the variation in surface area of the different types of fibers.

In addition, mixture design procedures showed that the incorporation of fibers in an asphalt paving mixture will increase the resulting air void content when compactive effort remains constant. Furthermore, as the quantity of fibers increases, the amount of air voids also increases. This is important from the standpoint of achieving a desired pavement density, since the mixtures with fibers will require more compactive effort than a mixture without fibers.

Hveem Stability. The addition of fibers in this asphalt concrete mixture generally resulted in no significant change in Hveem stability. Hveem stability is more closely related to asphalt content than the presence or type of fibers. That is, Hveem stability generally decreases as the design asphalt content of the various mixtures increases.

Marshall Stability. Generally Marshall stabilities of fiberized mixtures are not significantly different from the control mixture. These data showed that while fibers increase the optimum asphalt content, they also decrease the mixture's sensitivity to asphalt content. More than one-half the fiber mixtures exhibited a significantly greater Marshall flow than the control specimens.

Indirect Tension with Fibers

Indirect tension tests were performed at 77°F and two inches per minute on fiberized asphalt mixtures (1). Figures 1 and 2 show that tensile strength is generally lower and tensile strain at failure is higher for the fiber mixtures when compared to the control mixture. Statistical analyses showed that tensile strength of nine of the fifteen fiber mixtures was not significantly different ($\alpha = 0.05$) from the control specimen. Further, tensile strain at failure of seven of the fiber mixtures was significantly greater than that of the control mixture. This is likely due, in part, to the additional asphalt as well as the fibers in these mixtures.

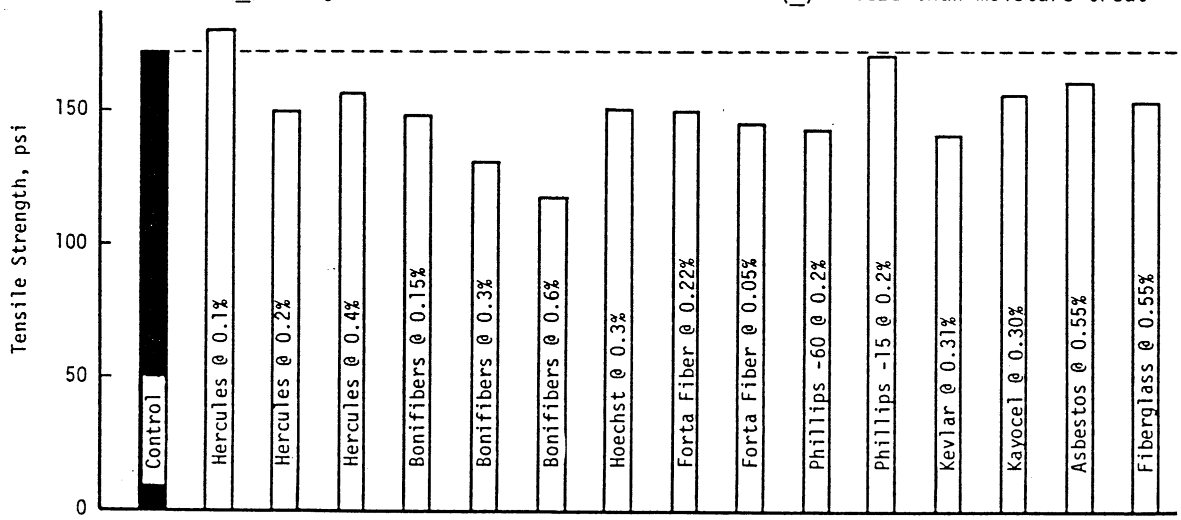


Figure 1. Tensile Strength of Gyratory Compacted Specimens Tested at 2 in/min and 77°F.

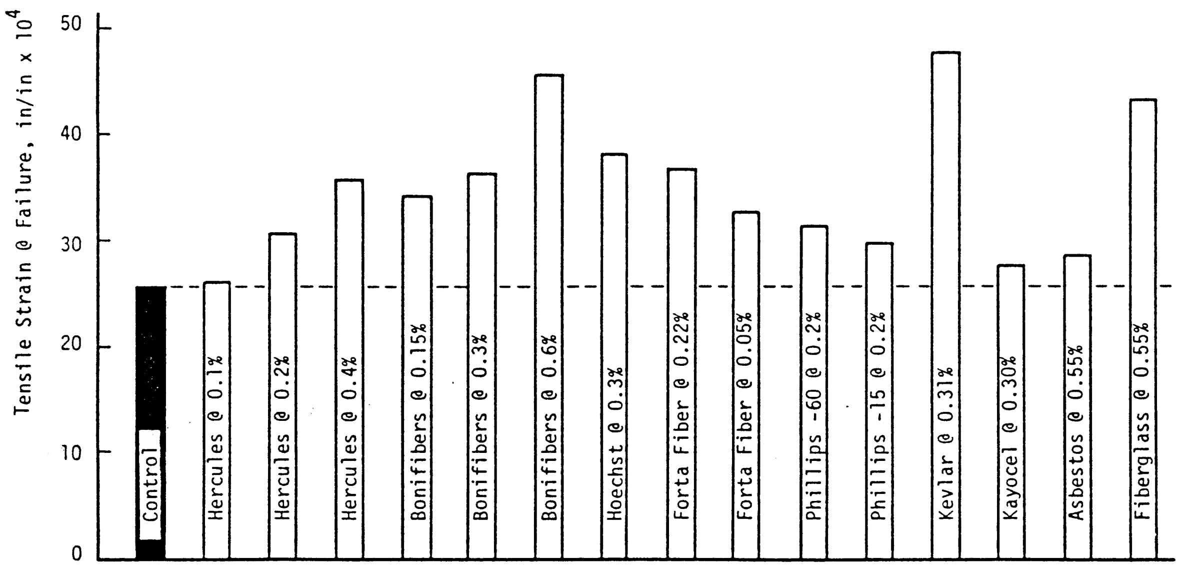


Figure 2. Tensile Strain at Failure of Gyratory Compacted Specimens Tested at 2 in/min and 77°F.

Moisture Susceptibility with Fibers

Indirect tensile tests were conducted before and after the specimens were exposed to the Lottman (6) freeze-thaw moisture treatment. Ratios of tensile strength before and after moisture treatment were computed. The mixtures containing fibers generally exhibited significantly greater tensile strength ratios than the control specimens.

It is important to remember that the mixtures containing fibers had greater asphalt contents and yet greater void contents than the control mixture. Regarding resistance to moisture damage, these two parameters would be expected to oppose one another. It is surmised, therefore, that the additional asphalt in the fiber mixtures increased the film thickness on the aggregate particles thus affording additional protection from moisture.

Creep and Permanent Deformation with Fibers

Creep. Direct compression tests were performed (1) at 40, 70 and 100°F on the control mixture and three mixtures containing 0.3 percent Hercules (polypropylene) fibers with 4.6, 4.85 and 5.1 percent asphalt (1).

Direct compression tests include incremental static loading, 1,000 second creep test and repeated haversine loading (dynamic test) for 1,000 cycles. These tests were performed in accordance with the VESYS IIM Users Manual (7) using 4-inch diameter and 8-inch height cylindrical test specimens.

Figure 3 depicts creep compliance for

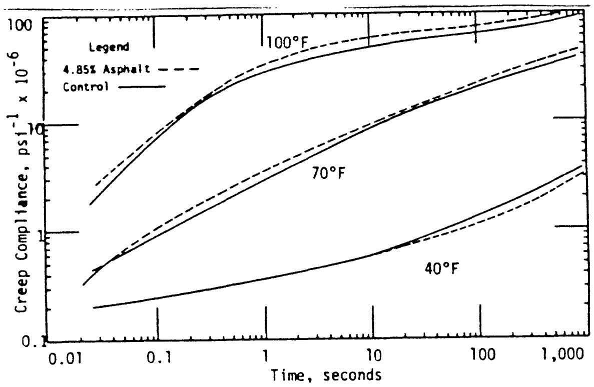


Figure 3. Creep Compliance Curves for Specimens Containing 4.85 Percent Asphalt and Control Specimens.

the fiber mixture containing 4.85 percent asphalt. These curves are also fairly typical of those fiber mixtures containing 4.6 and 5.1 percent asphalt. However, as the asphalt content was increased, the fiber mixtures became more compliant than the control mixtures at 70 and 100°F but exhibited about the same compliance as the control mixtures at 40°F. At lower temperatures, when asphalt cement becomes more elastic, an asphalt paving mixture is less sensitive to asphalt content in this test mode. This may, in part, explain why the fiber mixtures with the higher asphalt contents exhibited greater compliance than the control mixture at the higher temperatures.

Permanent Deformation. The specimens used on the creep tests were also used for permanent deformation testing. Accumulated permanent strain, versus number of load applications from the incremental static and dynamic loading tests are plotted in Figure 4. The plot indicates that, generally, permanent deformation of the fiber mixtures is about the same as that of the control mixture at higher temperatures where rutting is a concern; whereas, at lower temperatures, fibers appear to reduce permanent strain.

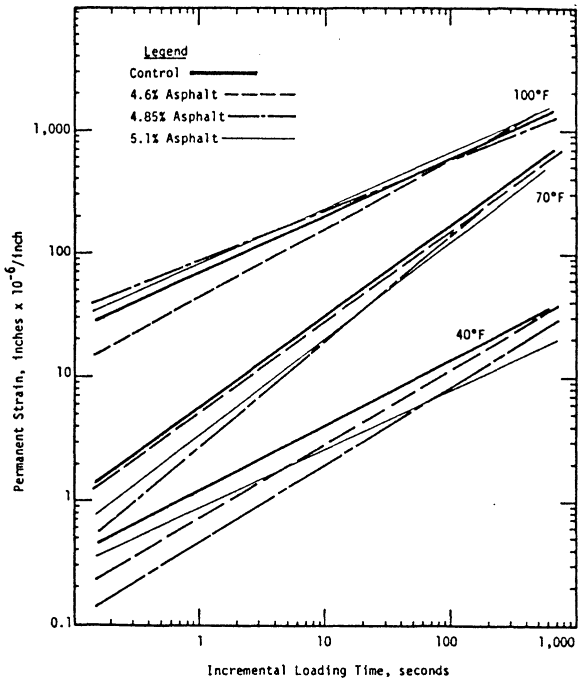


Figure 4. Permanent Strain from Incremental Static Loading Tests at 40, 70 and 100°F.

Direct Tensile Tests with Fabrics

Uniaxial tensile tests were conducted on asphalt concrete specimens containing a fabric at 2-inches per minute (5.1 cm/min) and 68°F (20°C) (2). Test specimens were 1.5 x 1.5 x 5-inches (38 x 38 x 135mm) in size with a strip of fabric located longitudinally in the central plane.

There was some variation in air void content of the specimens. Since air void content can have considerable effects on the tensile properties of asphalt concrete, measurements of tensile properties were normalized to estimate the value of stress and strain that would have been obtained if all specimens had contained the same amount of air voids. Test results showed that the fabrics did not consistently improve tensile strength of the specimens whether the low, optimum or high asphalt tack coat value was used. In general, the fabrics did effect a slight improvement in ultimate tensile strain. The most encouraging observation from these tests was the rather remarkable increase in initial tangent modulus when a fabric was employed (Figure 5). This implies that the fabrics begin to reinforce the paving mixture at very low levels of strain. That is, pavement service life should be extended when repetitive working stresses are significantly less than that required to cause immediate failure. This conclusion was verified, as will be seen, by laboratory fatigue-type tests.

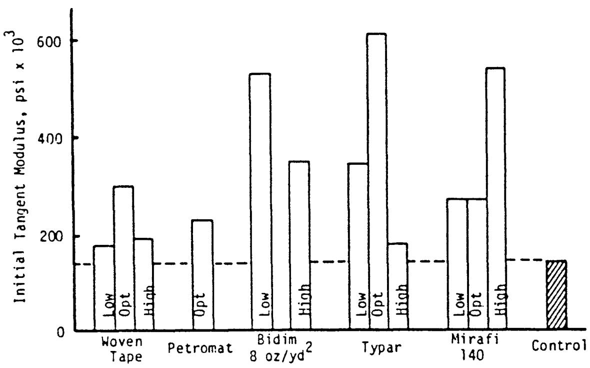


Figure 5. Average Initial Tangent Modulus of Tensile Test Specimens.

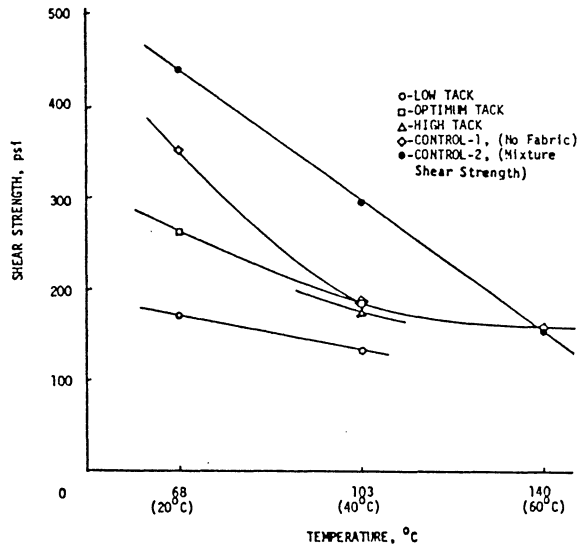


Figure 6. Overlay Shear Test Results with Mixtures using Mirafi 140.

Interface Shear Strength with Fabrics

When asphalt concrete overlays are applied, adequate shear strength must be attained or pavement slippage failures will occur. Slippage failures, characterized by crescent shaped cracks, are most likely to occur during braking or turning operations when ambient temperatures are high. There was concern that fabrics applied to reduce reflection cracking in asphalt concrete overlays might increase the probability of slippage at the fabric-pavement interface. A test method was developed which simulates the braking action of a wheel on an overlaid pavement and was used to determine the shear strength of the interfaces between the old pavement and the new overlay (2). Tests were conducted at 68, 104 and 140°F (20, 40 and 60°C, respectively) at a deformation rate of approximately 13 inches per second (330 mm/sec). A static vertical pressure of 67 psi (460 kPa) was applied to the 3 x 3 x 2-inch (75 x 75 x 50 mm) cuboidal samples. Specimens at 140°F were quite soft and were, therefore, tested with no appreciable vertical load. Specimens were prepared with (1) only a 0.05 gallon per square yard asphalt tack coat at the interface (Control-1), (2) a fabric at the interface (5 fabrics were tested each with three asphalt tack quantities), and (3) no interface (Control-2). A typical example of the test results are given in Figure 6.

As expected, the mixture shear strength (Control-2) is in excess of the interface shear strength (Control-1). At the calculated optimum tack coat and at low temperatures the shear strength of those samples without a fabric at the interface (Control-1) is usually greater than the shear strength of those samples with a fabric at the interface. At the higher temperatures the shear strength of samples with fabric at the interface approaches the shear strength of those samples without fabric at the interface.

The tack coat quantity called "high" was twice the optimum quantity and was without doubt more asphalt cement than should be used in an actual overlay operation. It was anticipated that the excess tack would act as a lubricant and thus decrease the shear strength, particularly above 100°F. However, shear strength actually increased with increased tack coat for most of the fabrics. The increase in shear strength with increased tack coat was probably due to excess asphalt which migrated into the mixture adjacent to the shear plane thus creating a more tenacious bond in the critical area.

Based on these data, fabrics have little effect on interfacial shear strength at the higher temperatures where pavement shear strength becomes critical. Fabrics will, however, decrease interface shear strength at lower temperatures where shear strength is already more than adequate.

Beam Fatigue Tests

Beam fatigue tests were conducted on 3 x 3 x 15-inch specimens, loaded upward in a constant load test, and pulled back down to the original pre-test location in order to simulate the action of an elastic subgrade. The upward loading is to eliminate the effect of the sample weight upon the test results. Vertical deflection is measured with a linear variable differential transformer (LVDT) about 20 to 30 times during a typical test, and the return to its original position is controlled by the LVDT reading. Test data are analyzed by two different, but related, methods: one by the fatigue equation and the second by use of fracture mechanics. The fatigue equation is

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

where N_f = the number of cycles to reach failure in the fatigue test,

ε = the calculated strain in the sample on the 200th load repetition, and

K_1, K_2 = phenomenological constants derived from a series of tests made at different strain levels.

Tests are normally performed at 68°F (20°C) but Texas A&M has the capability of running tests in environmental chambers from -40°F (-40°C) to +140°F (60°C). A linear relationship which is unique to each mix has been found between K_2 and $\log_{10} K_1$, a relationship which is explained when investigating the same relations using fracture mechanics. The linear relation provides a means of determining whether an additive or a reinforcing layer alters the fatigue properties of the mix. All points for a particular mix will fall on a straight line such as illustrated in Figure 7.

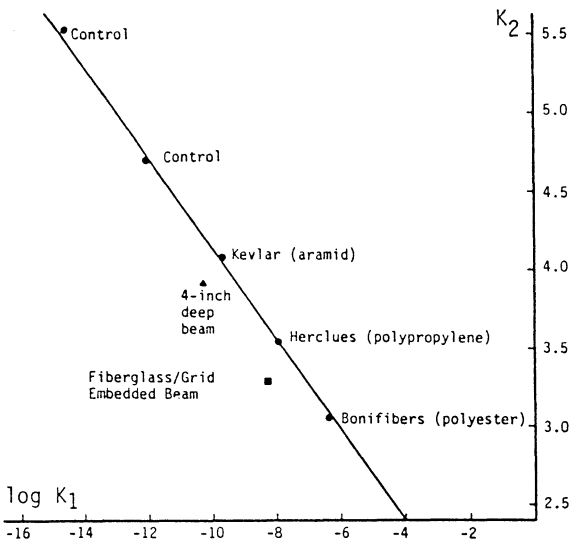


Figure 7. Flexural Fatigue Test Results on Fiber Mixes and Fiberglass Reinforced Beams.

If an additive or reinforcing layer improves the fatigue properties of the beam, the plotted point of K_2, $\log_{10} K_1$ will move off of the straight line and to the left of it. As seen in Figure 7, none of the fibers tested improved the fatigue properties of the mix. Plotted on the same graph are points measured using the same mix with fiberglass reinforcing grids. As seen in the Figure, the fiberglass grid shifted the value of log K to the left by about -1.3. Also shown is a beam fatigue test result using a four-inch deep beam with the same mix. The deeper beam causes a shift from the straight line relation, reducing $\log K_1$ by 1.0.

The same data may be analyzed using fracture mechanics which uses Paris' Law of crack growth (8):

$$\frac{dc}{dn} = A\,(\Delta K)^n$$

where c = the crack length,
n = the number of load repetitions,
dc/dn = the rate of crack growth, and
ΔK = the change of calculated stress-intensity factor with
A, n = fracture constants that are unique to the mix.

Applying this equation to the beam fatigue test shows that

$$K_1 = \frac{d^{(1 - \frac{n}{2})}}{A\,E^n}\, f\left(\frac{c_o}{d}, n\right)$$

$$K_2 = n$$

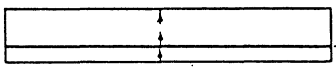
where $f(^{c_o}/d, n)$ = a function of the ratio of the original crack length to the depth of the beam sample.

The original crack length, c_o, is usually taken as the radius of the maximum aggregate size in the mix. The equation for K_1 shows that as long as n, the fracture exponent, $(=K_2)$ is larger than 2, a deeper beam will give a smaller value of K_1 (Figure 7). This is the primary reason that the deeper beam shifted the point in Figure 7 to the left. The fact that K_1 depends upon the depth of the fatigue sample has been observed experimentally for decades. The fracture mechanics approach shows why this is to be expected. Also, a larger modulus of the mix, E, and fracture coefficient, A, will decrease K_1. It has been demonstrated both theoretically (9) and experimentally (10,11) that the fracture coefficient, A, is also dependent upon E and n. Because $\log K_1$ and K_2 are both dependent upon the same variable, n, the fracture exponent, it is not surprising that there is a linear relationship between them.

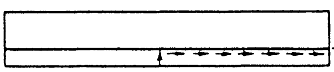
Overlay Tests

The "overlay test" was developed at Texas A&M (11) to simulate the thermal opening and closing of cracks or joints in the old pavements beneath an overlay. A beam is epoxied to a horizontal surface made of a fixed and a moveable platen, with half of the length of the beam resting on each platen. The moveable platen is opened and closed a preset amount (between 0.01 and 0.07 inches) and a crack propagates upward through the beam sample. The load versus displacement relation is measured. Crack height is measured on both sides of the sample and is observed most clearly by painting the sample white in the crack propagation zone prior to the test.

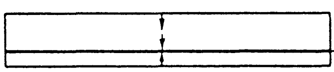
It has been discovered that the mode of failure reveals the nature of the material tested. Three distinct modes of failure have been observed (Figure 8).



Failure Mode I: Crack Propagates from Bottom to Top



Failure Mode II: Crack Penetrates to Fabric Bottom then Develops Slippage Plane Below Fabric



Failure Mode III: Crack Propagates to Fabric Bottom then Starts Again at Top of Sample and Propagates Downward.

Figure 8. Modes of Sample Failure.

Modes I and III occur when the material in the overlay acts as a "strain-relieving" layer and Mode II occurs when the material "reinforces" the overlay. "Reinforcing" can only occur if the material has a higher modulus than the overlay material and sufficient cross-sectional area to substantially strengthen the overlay.

Analysis of Mode I Fracture. Paris' Law is used to analyze the growth of the crack upward through the overlay test beam. Paris' Law is

$$\frac{dc}{dn} = A\,(\Delta K)^n$$

As shown previously, the power n is equal to the value of K_2 on the beam fatigue tests. It has been found experimentally that there is a linear relation between log A and n, and the reasons for this dependence have been shown theoretically by Schapery (9). Unlike the relations between the beam fatigue constants K_1 and K_2, which depend upon the beam thickness, the relation between log A and n depend solely upon the properties of the mix and how they are altered by fibers, grids, or fabrics embedded in them. Shown in Figure 9

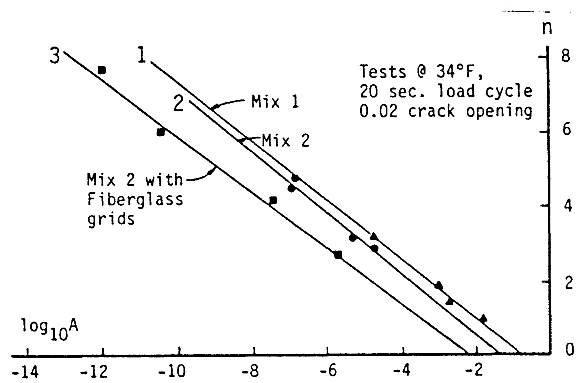


Figure 9. Relation Between Log_{10} A and n.

are typical graphs of log A versus n with lines for two different mixes. Line 1 is for a dense-graded crushed limestone with a 3/8-inch maximum size of aggregate and 4.5 percent AC-10 binder, and about 8 to 9 percent air voids. Line 2 is for a dense-graded crushed limestone with a 1/2-inch maximum size of aggregate, 5 percent AC-10 binder, the effect of a fiberglass grid embedded in the beam sample, in which the mix is the same as on Line 2. The shift of fracture properties is a counterclockwise rotation of the line, which results in a reduction of the crack growth rate. Similar shifts were observed with the polyethylene grid and with the fiberglass fabrics. For the most part, none of the other fabrics caused a systematic shift of the log A versus n line.

Analysis of Mode II Fracture. When Mode II fracture slippage occurs, a different kind of analysis must be done, which is illustrated in Figure 10. Free body diagrams are drawn of the upper and lower parts of the beam, showing all of the forces acting on each. The two parts of the beam are held together with the shear stress distribution shown in Figure 10b. The assumed shear stress-versus-displacement relation shown in Figure 10c has a linear portion until slip occurs, after which a constant shear stress, τ_{min}, is assumed. In the upper part of the beam shown

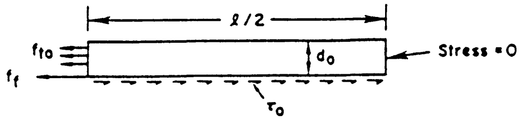


Figure 10 a. Upper Part of Overlay Sample

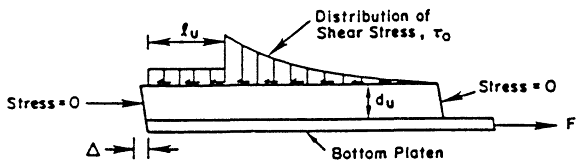


Figure 10 b. Lower Part of Overlay Sample

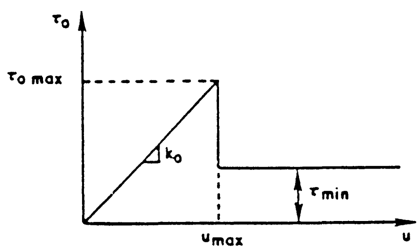


Figure 10 c. Assumed Shear Stress Versus Shear Displacement Relation

in Figure 10a, the force in the fabric and the force in the layer above the fabric must equal the force generated by the shear stress distribution. The simultaneous equations that arise from the equations of equilibrium of the two free bodies in Figures 10a and 10b have more unknowns than there are equations unless the strain in the upper layer is measured. Because it has been the practice at Texas A&M to measure the strain of the top fiber in the overlay test, it has been possible to determine the force in the fabric, $f_f \, t_f$, the stress in the upper layer, f_{to}, the shear stiffness of the tack coat beneath the grid or fabric, and the shear stress after slippage occurs, τ_{min}. The relations between these variables and how they are related to the film thickness of the tack coat and the modulus of the grid or fabric are too extensive to be treated in this paper.

It is sufficient to state that the slippage fracture will not occur unless the thickness of the upper layer, and the modulus and cross-sectional area of the fabric or grid are sufficient to overcome the horizontal shearing forces beneath the reinforcing layer.

FIELD OBSERVATIONS

A portion of the research program was devoted to field evaluations of pavement interlayer systems (1 - 5) to establish their relative performance.

Fabrics

Construction. The following observations were made during overlay construction when fabrics were applied (4).

1. Pneumatic rolling of the fabric immediately after application will maximize adhesive strength and shear resistance and minimize its disruption by traffic, construction equipment or wind.
2. Fabrics with a somewhat "fuzzy" surface next to the asphalt tack offer more resistance to slippage (and thus wrinkling) under tires of construction equipment than the smoother surfaced fabrics.
3. Fabrics which exhibit free shrinkage in excess of 5 percent upon exposure to 300°F for 30 minutes have been related to hairline cracks that appear during construction at wrinkles or improperly overlapped cuts in the fabric.
4. Traffic action can delaminate and/or remove fibers from fabrics. Some types of fabrics are more susceptible to this phenomena than others.
5. Exposure of fabric to prolonged rainfall and traffic action immediately after installation can adversely affect the fabric-to-pavement bond. In severe cases, isolated areas of fabric may become completely separated from the pavement. A highly textured pavement surface, where there are significant voids between the fabric and the pavement surface, will aggravate this situation.

Performance. There is no strong evidence that a fabric interlayer provides a universal mechanism for extending the crack-free life of an overlay (4, 12). Fabrics appear to be most suited for reducing the reflection of closely spaced cracks such as alligator cracks in mild climates. Generally, fabrics do not exhibit good performance over pavements with widely spaced transverse cracks.

Test pavements containing various combinations of fabric, sealcoat and HMAC overlays were installed in Midland County, Texas in 1973 and 1974. Percent reflection cracking as a function of time is given in Figure 11(13).

Fibers

Observation of the two field test installations (1) showed that, in one instance, fibers appeared to reduce reflection cracking, but in the other, fibers had little effect on

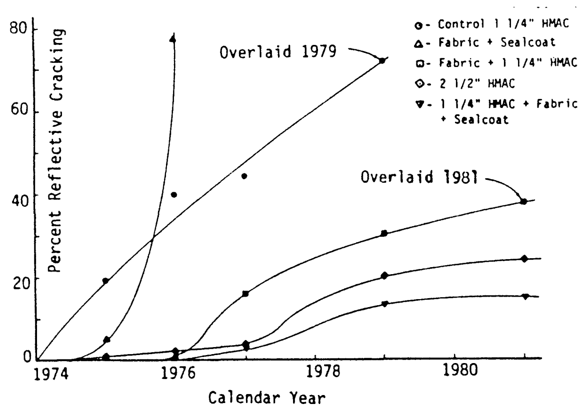


Figure 11. Reflection Cracking Progression for Selected Rehabilitative Treatments.

reflection cracking. Review of field tests conducted by other agencies indicates that synthetic fibers in hot mixed asphalt concrete will often reduce reflective cracking. Further, states in the north, with colder climates, reported better results with fibers than states in the south.

Synthetic fibers can be damaged by heat. Mix temperature should not exceed 290°F when polypropylene fibers are used.

PROGRAM SIMPLE

Program SIMPLE is named so because of the simplifying assumptions that have been made in order to assemble the entire program, which is a mechanistic-empirical method of computing the reflection cracking life of overlays, taking into account the combined influence of traffic and thermal stresses on reflection cracking.

The program makes up for the simplifying assumptions by being "calibrated" to the field data on reflection cracking of overlays which were observed in Texas (see Figure 7) and New Mexico. "Calibration" amounted to finding a multiplying factor which converts the predicted number of days to reach the reflection cracking life of an overlay into the actually observed number of days.

CONCLUSIONS

Fabrics

1. Laboratory tests indicate fabrics will improve the tensile properties of asphalt concrete at low strain levels, increase flexural fatigue life and improve resistance to thermal reflective cracking. These improvements can be maximized when the optimum asphalt tack rate is carefully selected. These data imply that fabrics can function as an effective strain-relieving interlayer in asphalt concrete pavements.
2. The potential for overlay slippage at the fabric-pavement interface is no greater for properly installed fabric systems than for conventional overlays.
3. Proper construction of overlays with fabric-bitumen interlayers is crucial to its good performance. Wrinkles, bubbles caused by trapped water vapor, traffic on the exposed fabric, placing a fabric directly on the old pavement, or under a thin (less than 1 1/2 inch) overlay, or with too much or too little tack coat can all cause problems to the subsequent performance of the overlay. Moisture trapped beneath a fabric-bitumen layer can lead to stripping as can moisture trapped on top of the fabric at the bottom of a thin, porous overlay.

Fibers

1. Generally, Hveem and Marshall stability of a paving mixture is not altered significantly by the addition of synthetic fibers.
2. A given dense graded asphalt paving mixture containing synthetic fibers will require more compactive effort to produce a pavement density equal to that normally obtained without fibers.
3. Indirect tension tests revealed that, overall, the addition of fibers to a paving mixture will cause a slight decrease in tensile strength and a slight increase in tensile strain (elongation) at failure. The increased tensile strain at failure is likely due, at least partly, to the additional asphalt as well as the fibers in these mixtures and shows that fibers and additional asphalt add flexibility or extensibility to asphalt concrete.
4. Based on a limited number of constant-stress flexural fatigue tests, it appears that synthetic fibers do not significantly affect fatigue performance of asphalt concrete paving mixtures.
5. Laboratory tests on fiber and nonfiber asphalt mixtures at 33 and 77°F indicate that fiber mixtures will exhibit significantly greater resistance to crack propagation at relatively high strain levels. Apparently, the fibers aid in distributing the stresses away from the crack site.

Grids

Grid-bitumen interlayers are not susceptible to the moisture problems mentioned above but do have cracking problems associated with wrinkles or rolls in the grid as it is placed. A seal coat or slurry seal placed over the grid appears to provide several good features to the overlay including strain relief.

REFERENCES

1. Button, J. W., and Hunter, T. G., "Synthetic Fibers in Asphalt Paving Mixtures", Research Report 319-1F, Texas Transportation Institute, Texas A&M University, January 1983.

2. Button, J. W., Epps, J. A. and Lytton, R. L., "Laboratory Evaluation of Fabrics for Reducing Reflection Cracking", Research Report RF 3424-3, Texas Transportation Institute, Texas A&M University, January 1983.

3. Button, J. W., and Epps, J. A.,"Evaluation of Mirafi Fabrics for Pavement Overlays", Research Report 3424-6, for Mirafi Inc., Texas Transportation Institute, Texas A&M University, January 1983.

4. Button, J. W., and Epps, J. A.,"Evaluation of Fabric Interlayers", Research Report 261-2, Texas Transportation Institute, Texas A&M University, November 1982.

5. Epps, J. A., and Button, J. W.,"Fabrics in Asphalt Overlays - Design, Construction and Specifications", Research Report 261-3F, Texas Transportation Institute, Texas A&M University,November 1984.

6. Lottman, R. P., "Laboratory Test Method for Predicting Moisture-Induced Damage to Asphalt Concrete", Transportation Research Record 843, Transportation Research Board, National Academy of Sciences, Washington, D.C.

7. Kenis, W. J., "Predictive Design Procedures, VESYS Users Manual - An Interim Design Procedure for Flexible Pavements Using the VESYS Structural Subsystem", U.S. Department of Transportation, Federal Highway Administration, Report No. FHWA-RD-77-154, 1978.

8. Paris, P. C., and Erdogan, F., "A Critical Analysis of Crack Propagation Laws", Transactions of the ASME, Journal of Basic Engineering, Series D, 85, No. 3, 1963.

9. Schapery, R. A., "A Theory of Crack Growth in Viscoelastic Media", Mechanics and Materials Research Center, Texas A&M University, College Station, Texas, 1973.

11. Germann, F. P. and Lytton, R. L., "Methodology for Predicting the Reflection Cracking Life of Asphalt Concrete Overlays", Research Report 207-5, Texas Transportation Institute, Texas A&M University, March 1979.

12. ___________, "Reducing Reflection Cracking in Bituminous Overlays - Status of Synthetic Fabrics", National Experimental and Evaluation Program, Project No. 10, Federal Highway Administration Memorandum, March 9, 1978.

13. Neal, R. S., Unpublished data on test pavements in District 6. Texas State Department of Highways and Public Transportation.

14. Barber, E. S., "Calculation of Maximum Pavement Temperatures from Weather Reports", Bulletin 168, Highway Research Board, Washington, D.C., 1957, pp. 1-8.