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PAVING FABRICS FOR REDUCING REFLECTIVE CRACKING

Final Report

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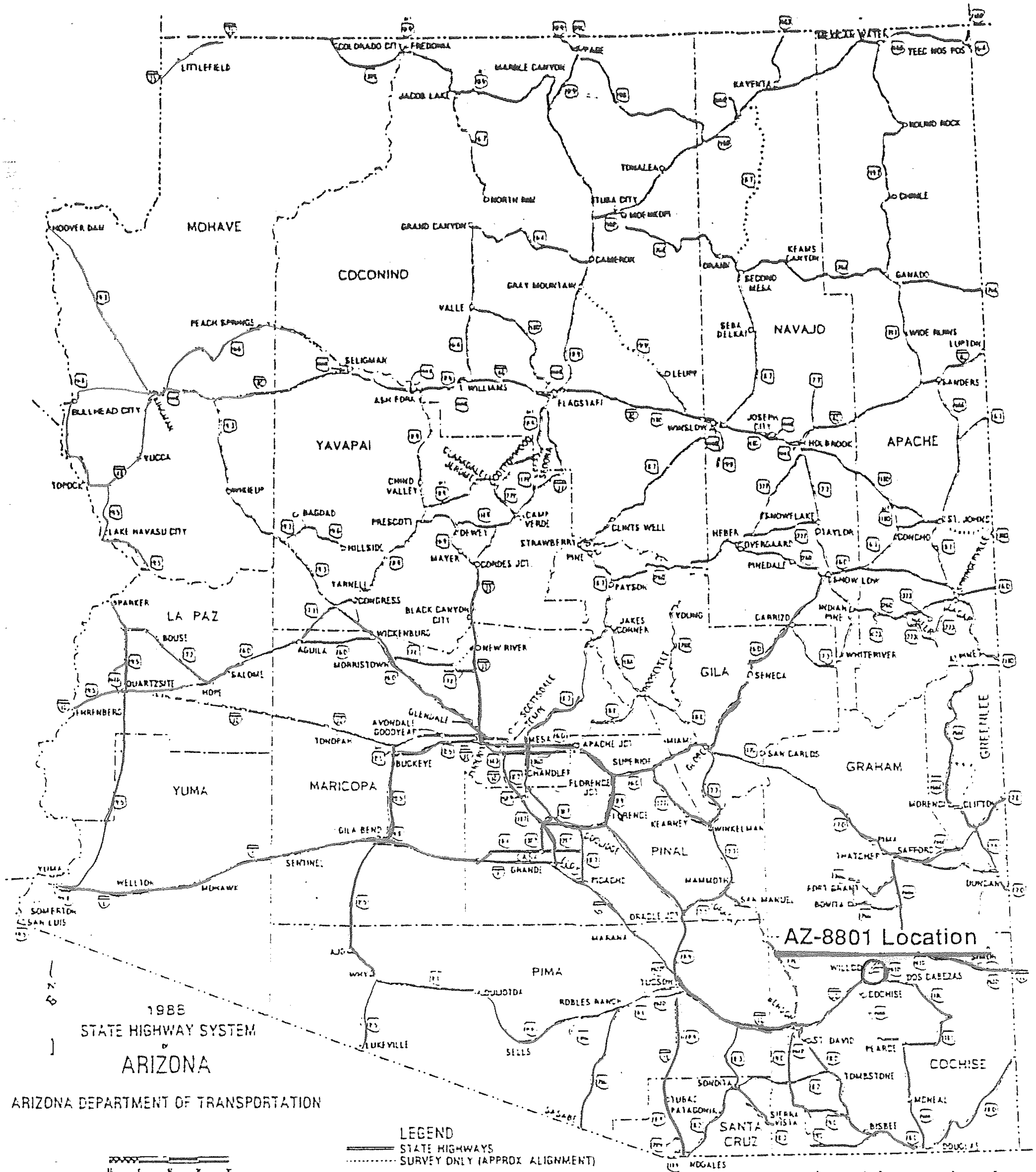

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16. Abstract

This research effort was part of ADOT's New Product Evaluation Program. The objective was to evaluate the construction and field performances of three commercially available paving fabrics; Paveprep, Glassgrid, and Tapecoat. The fabrics were designed to prevent or mitigate the propagation of reflective cracks through asphalt concrete overlays.

The experiment involved installing each of the fabrics onto eight full length transverse cracks along SR 186 in Willcox Arizona. Eight cracks were left untreated to be used as a control. After placement of the fabrics, the existing pavement was then given a 2-in. HMAC overlay. The locations of the original cracks were monitored for three years. In addition to the localized paving fabric, Travira Spunbound pavement reinforcing fabric was installed at full roadway length at the same time for a half-mile section just east of the experimental project. Although the Travira was not part of the experimental project, it's performance was also monitored.

The installation of the three paving fabrics was troublesome. The problems were primarily related to the fabrics' bond with the existing pavement. All of the fabrics had trouble developing a proper bond, and at times would pick up beneath the tires of the construction vehicles.

At the end of the evaluation period statistical analyses were conducted on the performance of the paving fabrics, relative to each other and to the untreated control cracks. The analyses showed no significant difference in the treated cracks or the control cracks. Core samples were obtained to confirm the fabric had stayed in place and that the cracks had propagated through them. The fabrics were not visibly distressed. Results of the evaluations led to the conclusion that these paving fabrics; Paveprep, Glassgrid, and Tapecoat, were ineffective at preventing or mitigating reflective cracking at the project location.

Paving fabrics are not recommended for future use on pavements with widely spaced transverse cracks. Recommendations for future investigations or use of paving fabrics include determining a means of insuring a proper bond of the fabrics with the milled original pavement.

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reflective cracks, paving fabrics, asphalt overlays, Paveprep, Glassgrid, Tapecoat, pavement rehabilitation, transverse cracks, reinforcing fabrics

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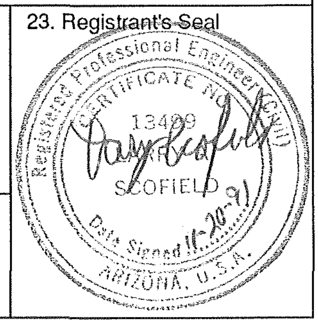

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INTRODUCTION

This final report is the result of an Arizona Transportation Research Center (ATRC) evaluation of three paving fabrics; Paveprep, Glassgrid, and Tapecoat. The project was performed in cooperation with the Federal Highways Administration (FHWA).

Background

Pavement rehabilitation is becoming an increasingly more important issue facing all levels of highway departments. The Arizona Department of Transportation (ADOT) is no exception. ADOT is responsible for more than 5,900 centerline miles of asphalt concrete (AC) pavement[1]. In the next 10 to 20 years, the majority of this asphalt pavement will require major rehabilitation or replacement in order to maintain it's current level of performance.

A common form of rehabilitation of hot mixed asphalt concrete (HMAC) pavement is the application of AC overlays. A problem, however, with using overlays has been the propagation of the original cracks from the pavement through the overlay. This process is referred to as reflective cracking and often occurs after only 1 or 2 years. Reflective cracking can significantly reduce the performance level of the pavement in a very short time.

Many different techniques of reducing reflective cracking have been tried. Among these techniques are the use of stress absorbing membranes, asphalt-rubber binder, thicker overlays, asphalt additives, and paving fabrics. Some of these methods can reduce the amount and rate of reflective cracking, but currently there seems to be no effective method of completely eliminating the propagation of cracks through an AC overlay to the surface.

Arizona has had some success mitigating reflective cracking with the use of full-width asphalt rubber stress absorbing membrane interlayers (SAMI). However, in some cases the existing pavement only has localized distress and it is not economical to apply a SAMI across the entire pavement. For projects where only portions of the pavement require treatment, a cost effective means of reducing reflective cracking is desirable.

Objective

Three paving fabrics; Paveprep, Glassgrid, and Tapecoat, were submitted by their manufacturers to ADOT's Product Evaluation Program. In June,1987, the Product Evaluation Committee recommended that the paving fabrics be incorporated into an experimental project under the supervision of the ATRC. The purpose of the project was to evaluate the ability of the three paving fabrics to prevent or mitigate reflective cracking through an AC overlay.

PROJECT LOCATION

Site Determination

There were two asphalt overlay projects scheduled to go to bid in February, 1988 that were proposed as candidate test locations by the Materials section of ADOT. These projects were S-366-937 near Flagstaff, and RS-274-(8)P in Willcox. The Willcox project's original pavement had transverse cracks ranging from 0.5 to 1 in. wide and spaced with some uniformity, generally 100 to 150 ft. apart. About 2/3 of the 20 to 30 cracks observed ran relatively straight across the road. Because of the uniformity of the cracking, which favored experimental comparison of the products, and the size of the cracks, this construction project was selected to host the paving fabric experimental project. The project was situated on SR 186, locally designated as Rex Allen Drive, from MP 326.44 to 327.48.

Area Description

Willcox is located approximately 160 miles southeast of Phoenix and 70 miles east of Tucson. The town is in the northern half of the Sulphur Springs Valley in Cochise county. The project elevation is 4255 ft.. The average daily maximum and minimum temperatures by month are given in Figure 1. The area receives 11.89 in. of precipitation a year, with the monthly distribution depicted in Figure 2[2].

Willcox is a part of a closed basin that has an interior drainage to the Willcox Playa at the lowest part of the valley. The Willcox area is flat and the soils consist of unconsolidated alluvium, and poorly and moderately consolidated alluvium. The soils are highly alkaline.

The Project

Figure 3 is an illustration of the test section portion of the construction project where the three paving fabrics were placed on transverse cracks prior to overlay placement. The stations designated in Figure 3 are based on distances measured along the curb of the north side of the street from the reference station 24+30. Station 24+30 was used as the reference station since surveyors had marked it on the roadway. The corresponding crack location stations are inconsistent with the actual construction plans stations for the sake of simplicity in locating and identifying the cracks at future dates.

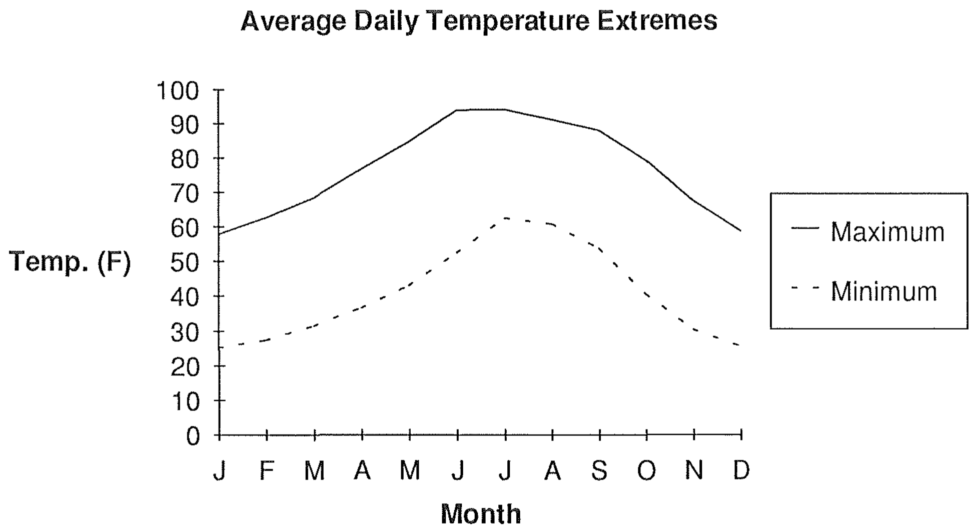


Figure 1 Average Daily Temperature Extremes, Willcox, Arizona[3].

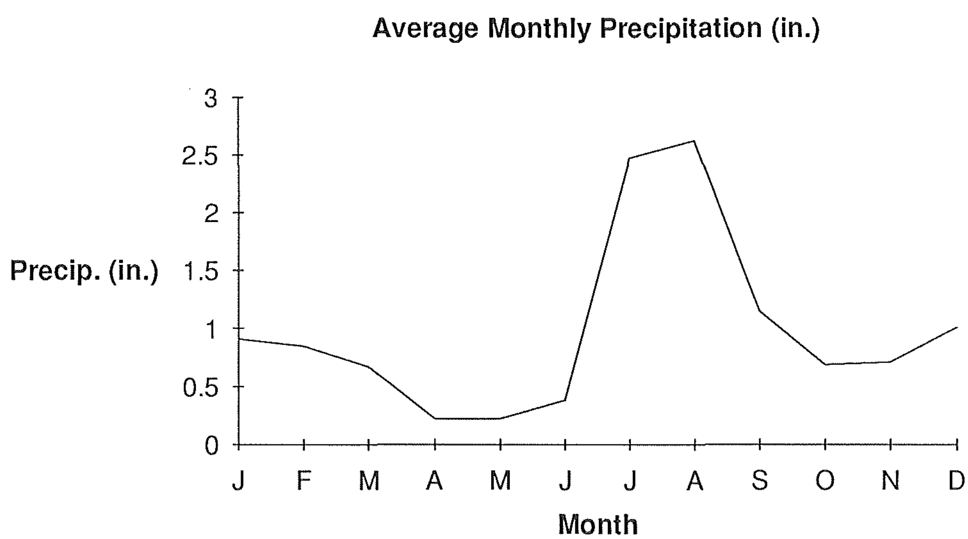


Figure 2 Average Monthly Precipitation, Willcox, Arizona[4].

RS-274(8)P
EXPERIMENTAL REINFORCING FABRIC INSTALLATION

*Location of Cracks by Stations**

CRACK ID	1A	1B	1C	1D	2A	2B	2C	2D	3A	3B	3C	3D	4A	4B	4C	4D
STATION	24 + 30	25 + 00	25 + 44	27 + 97	28 + 90	29 + 86	31 + 07	31 + 85	32 + 89	33 + 75	34 + 48	35 + 51	36 + 57	37 + 81	38 + 35	39 + 50
CRACK ID	5A	5B	8B	8A	5C	8D	5D	6A	6B	6C	6D	8C	7A	7B	7C	7D
STATION	40 + 50	42 + 13	42 + 89	42 + 33	45 + 45	46 + 27	46 +57	47 + 07	47 + 69	48+ 11	49 + 11	51+ 66	52 + 09	52+ 75	53 + 25	53 + 83

* *Stations referenced from crack 2A with distance measured along north curb.*

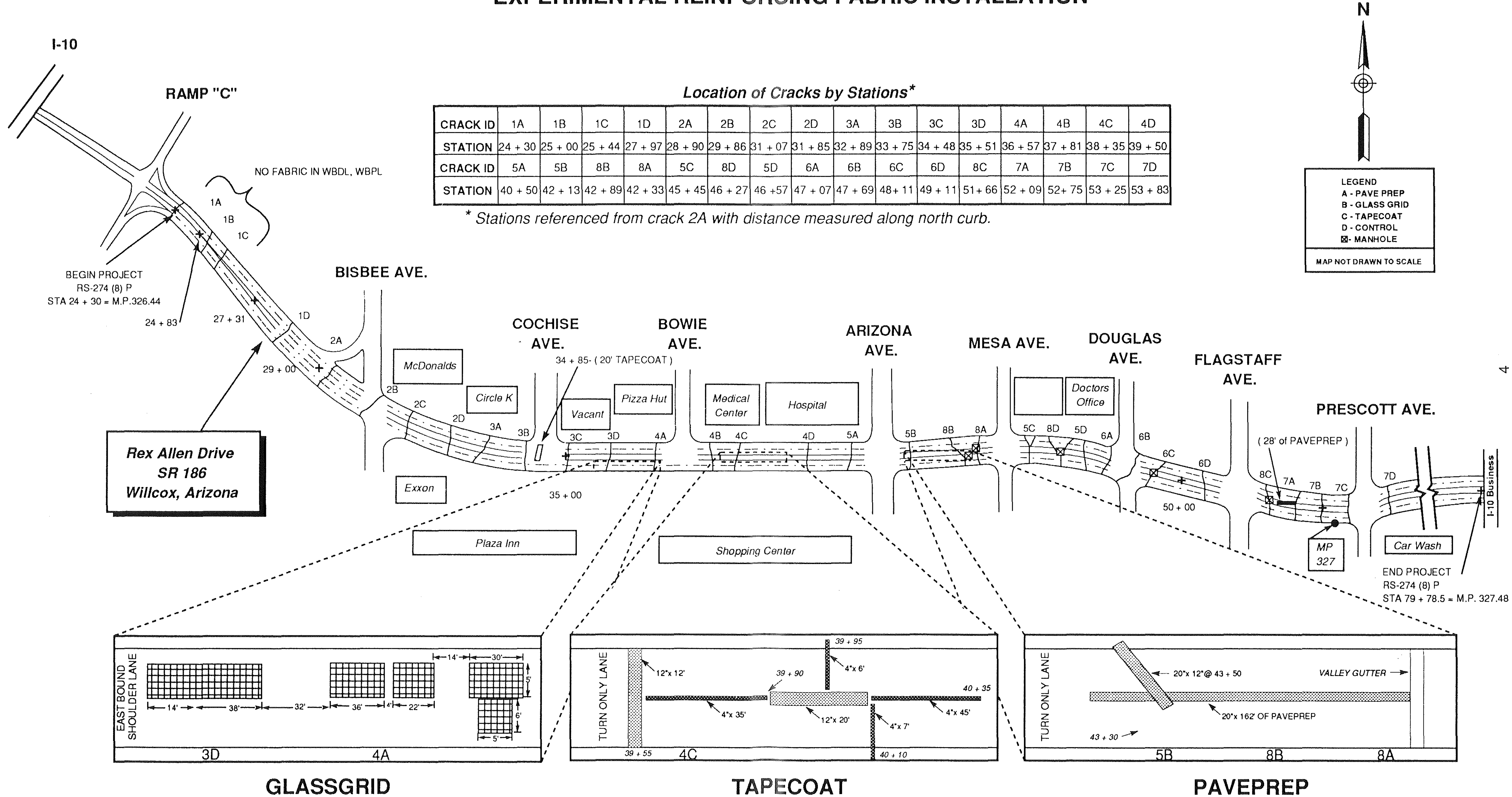


Figure 3 The Test Section.

EXISTING SITE DESCRIPTION

The Existing Roadway

The existing roadway was 64 ft. wide, with 2 lanes in each direction and a center turning lane for most of the project. The only exception is between stations 24+30 and 27+31 which did not have a center turning lane. The average daily traffic (ADT) is 5768 vehicles/day and consists primarily of passenger vehicles[5].

The existing pavement was constructed in 1971 and consists of 6 in. of cement treated base (CTB), 5.5 in. of asphalt concrete, and 0.5 in. of asphalt concrete friction course. The pavement design is illustrated in Figure 4.

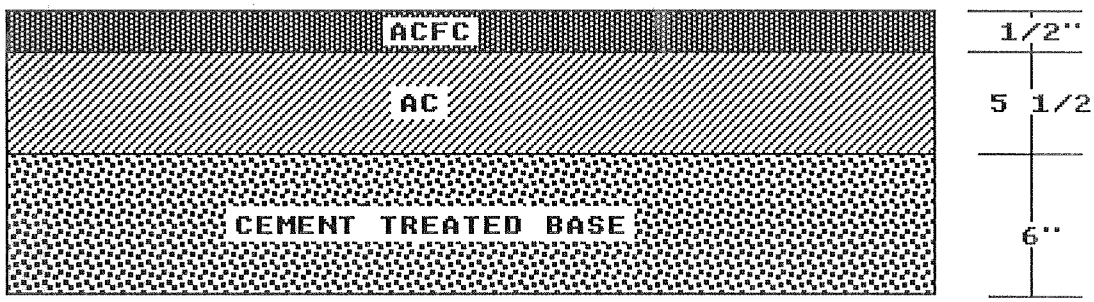


Figure 4 Original Pavement Section.

Existing Pavement Performance

Rex Allen Drive was in need for an overlay because the level of roughness and the amount of cracking was increasing rapidly. The cracking included 0.5 in. wide transverse cracks with occasional "random cracking" occurring throughout the project. The term random cracking is used in this report to designate cracking in the form of small-width longitudinal and alligator cracking, and small-length, small-width linear cracking either skewed or not skewed in the transverse direction.

Figure 5 shows a typical transverse crack in the pavement. Most of the transverse cracks had been filled with sealant, but much of the sealant had been tracked onto the pavement. The cracks had been filled with dirt and small incompressibles. The portland cement concrete curbs, gutters, and sidewalks in the vicinity were badly cracked, as shown in Figure 6. It appears as though moisture intrusion into the subgrade may have increased the severity of the cracking.

Drainage on the road was a problem, and still is. There is no provision for removing rain water from the street. As such, the water tends to settle along the curbs and gutters, migrating through cracks and joints into the base and subgrade. Figure 7 illustrates the drainage problem. Subgrade samples taken during the initial construction were determined to have a water content of 30.7 percent.

Figure 5 Typical Transverse Crack in the Pavement.

Figure 6 Typical Cracks in the Curb and Sidewalks.

Figure 7 Gutters Filled with Runoff.

EXPERIMENTAL PLAN

With the objective of evaluating the three paving fabrics' field performance at reducing reflective cracking on Arizona's highway pavements, an experiment was formulated to compare the three fabrics with each other and with the "do nothing" alternative. The experiment consisted of treating 32 high severity transverse cracks with the 4 treatment alternatives; Paveprep, Tapecoat, Glassgrid, and "do nothing". The "do nothing" treatment will also be referred to as the control, or the control treatment, in this report.

Eight replicates of each alternative were selected based on the number of full-width transverse cracks available. The eight replicates were spread over 8 different randomly determined locations in the test site, providing a statistical design that blocks the effect of location variability. Figure 8 shows the conceptual design of the experiment. The locations of the test cracks were marked with washers set in epoxy on the nearby curb to facilitate future monitoring and evaluation.

PRODUCT DESCRIPTIONS

The paving fabrics used in this experimental project were Paveprep, Glassgrid, and Tapecoat. Samples of promotional brochures provided by the manufacturers are given in APPENDIX A.

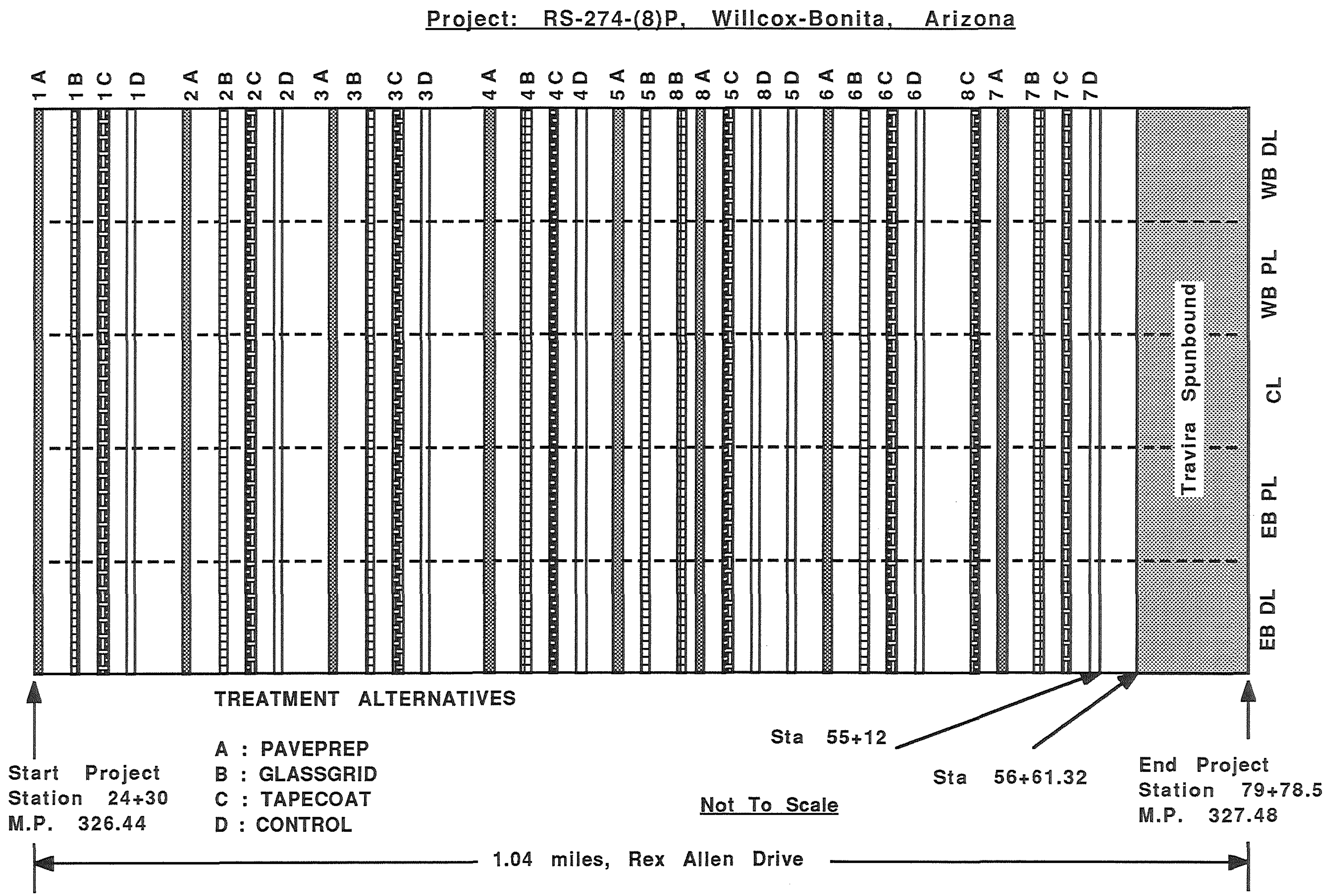


Figure 8 Experimental Design.

Paveprep is a high density polymerized asphalt mastic sandwiched between two layers of polyester fabric. Figure 9 is a photograph of the material with a tape measure labeled every 1 inch. The product is manufactured by International Coating Systems, Inc. and has previously been known as Prepave and Pre-Pave. Paveprep is 120 mils thick and is available in rolls of 12 to 42 inches. The product requires the application of an asphalt cement to bind it to the existing surface. The free-on-board cost of Paveprep is $9.00 per square yard. Five 20-in. wide rolls, each 102 ft. long, were used for the experimental project and were supplied free of cost by the manufacturer.

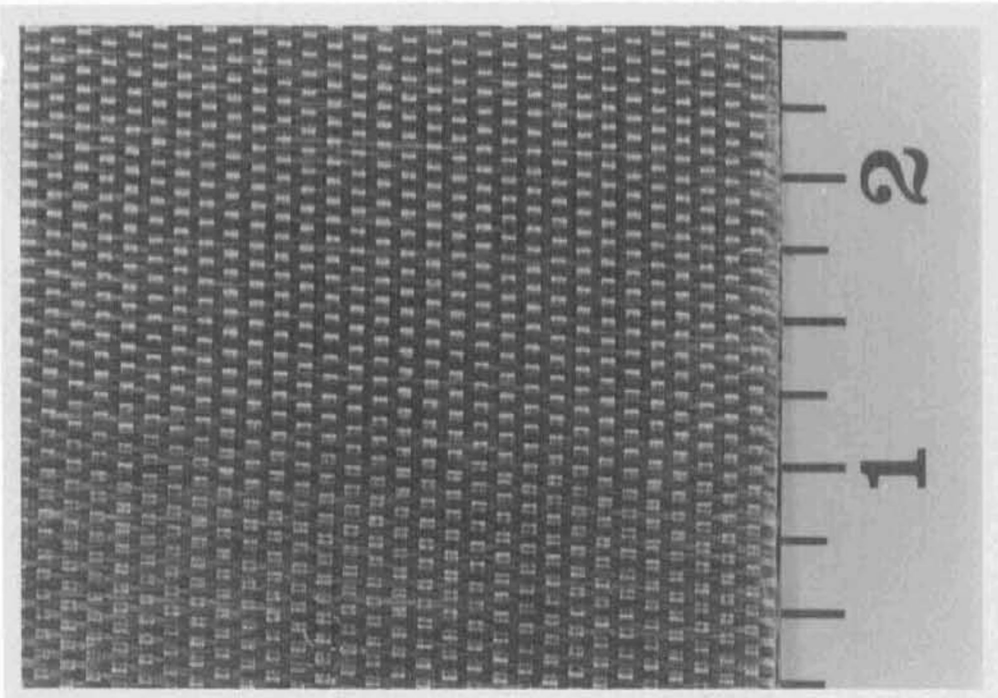


Figure 9 Paveprep Paving Fabric.

Glassgrid is a paving fabric composed of glass fibers bundled into strands which are held in place by polyester thread. The product is manufactured by Bay Mills Limited. Figure 10 is a photograph of Glassgrid with a tape measure in inches. The product's grid structure is the result of weaving the glass fiber strands together. Glassgrid comes in two different categories; the "detail repair", and "complete road" systems. The detail system has double strands and as such has a higher tensile strength and weight than the single strand complete system. For the Rex Allen Drive project, the detail system of Glassgrid was used. At the time of construction Glassgrid cost $2.25 per square yard, but was provided free of charge by the manufacturer.

Tapecoat M-860 is a pre-formed elastomeric resin bound with an adhesive to a woven polymer fabric. The product is cold-applied and self-adhering. Tapecoat M-860 is manufactured by The Tapecoat Company and is available in 4, 6, and 12 in. wide rolls 150 ft. long. Figure 11 depicts Tapecoat M-860 with a tape measure in inches.

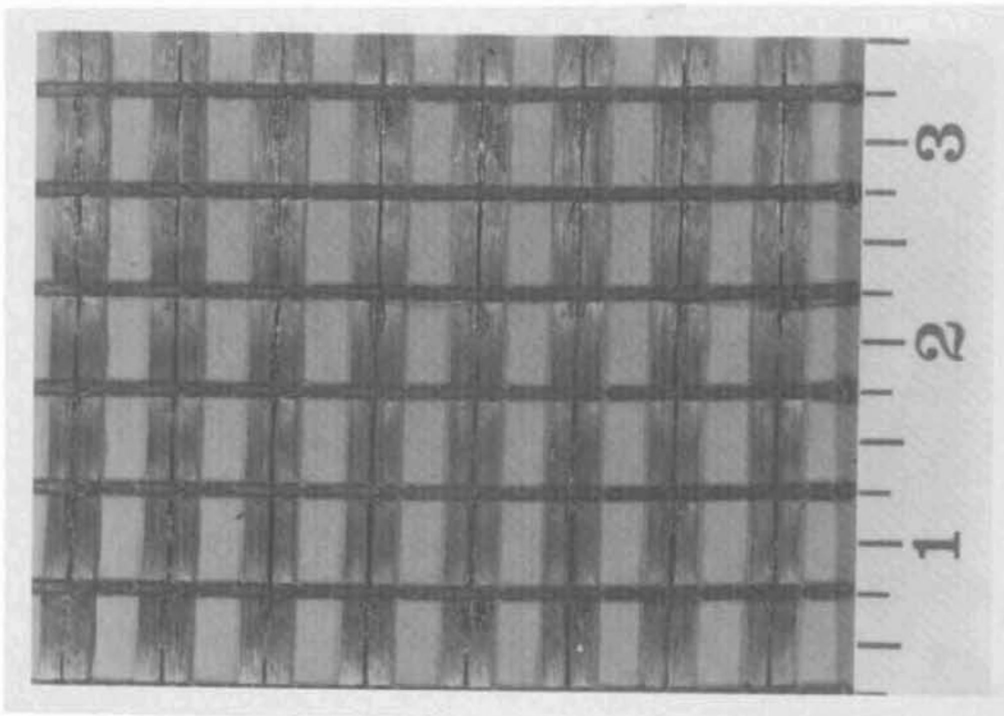


Figure 10 Glassgrid Paving Fabric.

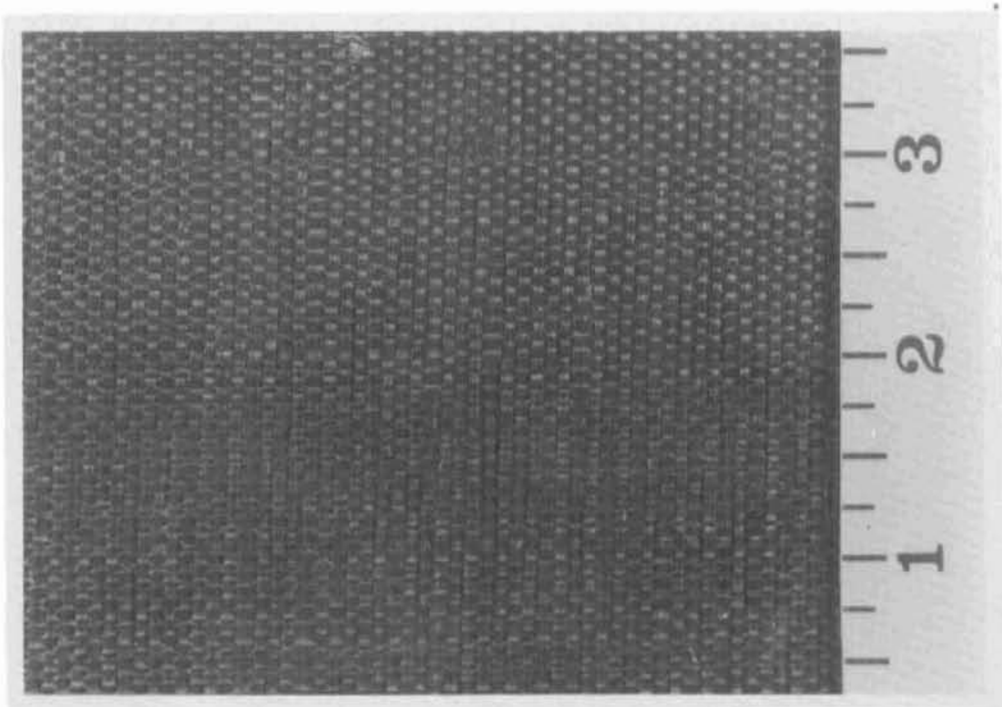


Figure 11 Tapecoat Paving Fabric.

The cost of Tapecoat was dependent on the amount purchased. A carton of Tapecoat consists of either one 12 in. roll, two 6 in. roles, or three 12 in. rolls, each of which result in 16.67 square yards of material. Estimated costs at the time of construction are $5.76 per sq. yd. for 1 to 12 cartons, $4.86 per sq. yd. for 13 to 71 cartons, and $4.14 for more than 71 cartons. For the experimental project, 12 in. wide rolls were used to treat the transverse cracks, and 4 in. wide rolls were used for the random crack treatments. The fabric was provided by Tapecoat free of charge.

CONSTRUCTION

The Construction Project

The construction project RS-274-(8)P consisted of removing, furnishing, and placing asphalt concrete, furnishing and placing pavement reinforcing fabric, constructing wheel chair ramps, and other incidental work.

The work under the pavement reinforcing item involved placement, with the use of mechanical equipment, a reinforcing interlayer between the milled surface and the surface course from station 56+61 to station 79+78. The item included furnishing all of the equipment, materials, and labor necessary for placing the fabric. The fabric was specified to be a nonwoven polyester, polypropylene, or polypropylene/nylon material conforming to the standards shown in Table 1. The contractor chose to use Travira Spunbound to fulfill this specification.

Weight, Oz,/sq.yd. ASTM Designation: D 1910	3.0 to 8.0
Grab Tensile Strength (1-inch grip), Pounds, ASTM Designation: D 1117	90 min.
Elongation at Break, % ASTM Designation: D 1117	40 min.
Fabric Thickness, ASTM Designation: D 461	30 to 100 mils

Table 1 Specifications for Pavement Reinforcing Fabric.

Specifications required surface preparation and a binder coat of paving grade asphalt (AC-30). The milled surface was to be open to normal traffic in not more than 72 hours, and the bare reinforcing fabric was specified not to have public traffic other than turning vehicles. The rate of binder coat application was specified as the range of 0.25 to 0.30 gallons/square yard, with an additional recommendation that the application rate reduced by 20% at intersections to minimize the chance of developing a slippage plane.

The experimental fabric installation specifications called for furnishing and applying the 3 experimental fabrics to function as interlayers between the milled surface and a 2-in. AC overlay. The fabrics were supplied by their manufacturers, however the contractor was responsible for furnishing the equipment, materials, and labor required to apply these fabrics on the milled surface directly over the selected transverse cracks.

General Construction Procedures

ADOT District 2 provided the contract administration, materials testing and construction inspection of the construction project, including the experimental project section. Mr. Noland Durnell was the resident engineer. The construction contract was awarded to the Ashton Company for $254,815. Rail-H was subcontracted to mill the pavement. Construction of the project began August 1, 1988, and paving began August 8, 1988. The bid items with associated quantities and unit prices are included in APPENDIX B. ADOT special provisions for installing the pavement reinforcing fabric and the experimental fabrics are given in APPENDIX C. A list of personnel who observed, inspected, or supervised the project construction is given in APPENDIX D.

A Caterpillar milling machine was used to mill the top 2-in. of the existing pavement. The milling machine could only mill a 6 ft. wide trench, and as a result it took from Aug. 1 thru Aug. 5 to completely mill out the roadway. The sequence in which the milling took place is brought forth in Figure 12.

After milling, a power broom was used to clear the residue and debris left on the milled surface. Figure 13 is a photograph of the broom used by the contractor. Figure 14 is a photograph of the milled and broomed surface. Due to heavy rains, the contractor was unable to start paving until August 8, at which time the surface was re-swept with the power broom.

Paveprep

Eight transverse cracks, crossing 468 ft. of pavement, were treated with Paveprep. An additional 202' of random cracking was covered with the fabric. Paving was to be carried out by lane, and likewise so was the fabric treatment. The installation of Paveprep involved tacking the surface with AC-30, cutting and rolling out the fabric, and walking across it. The installation took place about 400 ft. ahead of the paving machine. Figure 15 shows a Paveprep installation.

During the placement of Paveprep there were problems with the fabric not adhering to the milled surface. Several methods were incorporated in an attempt to achieve a better bond. First, the contractor applied the binder coat for the entire overlay at the rate of 0.20 gal./sq. yd., rather than specified 0.25 to 0.30 gal./sq. yd., and then placed the Paveprep. This was not successful in creating a better bond. Next, the contractor tried to lay the fabric on an AC-30 tack, and then add the binder coat of AC-30. This strategy had limited success, however, the supplier of the AC-30 did not have a paving wand with a reinforced hose to apply the tack for the Paveprep placement. Instead, the spray nozzles on the back of the boot truck were turned on and off as the driver drove over the cracks. This led to problems with adequate coverage and proper quantities.

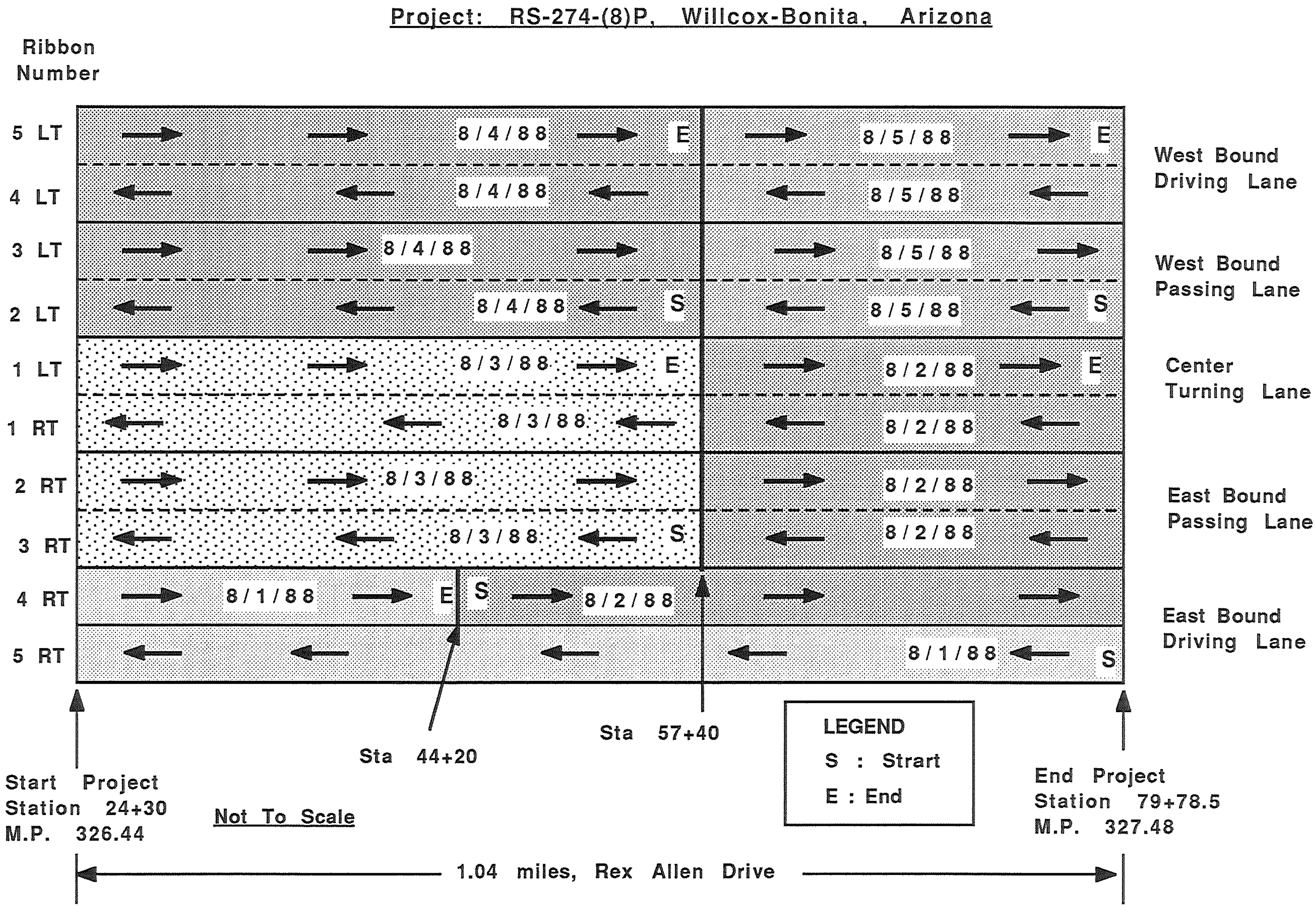


Figure 12 Milling Sequence.

Figure 13 Power Broom Used on Project.

Figure 14 Milled Pavement Surface.

Figure 15 Paveprep Installation on a Transverse Crack.

The boot truck carrying the AC-30 asphalt cement was not able to keep the asphalt within the desired temperature range of 320° F to 350° F. On the first day of paving (Aug. 8) the temperature of the AC-30 was recorded at 310° F. For the rest of the project the temperatures were much lower. On August 10, at approximately noon, the temperature of the AC-30 was observed at 225° F, and a sample taken from the end nozzle showed the temperature at 205° F. It was discovered that the level of asphalt in the truck was below the heating coils, and as a result, that amount of AC-30 could not be heated any further with the equipment that was being used.

During paving, the binder coat was sticking to the tires of the trucks and the laydown machine. As a result, when this equipment would cross over the paving fabric, the fabric would be pulled up by the equipment tires. Figures 16 and 17 illustrate instances where construction traffic had picked up some of the installed fabrics before placement of the overlay. Also, in some instances the fabric would tend to ball up in the overlay during compaction because of poor bonding with the existing surface.

After the first day of paving the binder coat for the overlay was changed from AC-30 to CSS-1 emulsion. CSS-1 is a cold-applied liquid emulsion. Figure 18 shows the specific locations where the two binder coats were applied. The boot truck with the AC-30 had been used for tacking the Paveprep and Spunbound. The paving fabrics did not get picked up on the tires of the construction traffic as frequently when the CSS-1 was used.

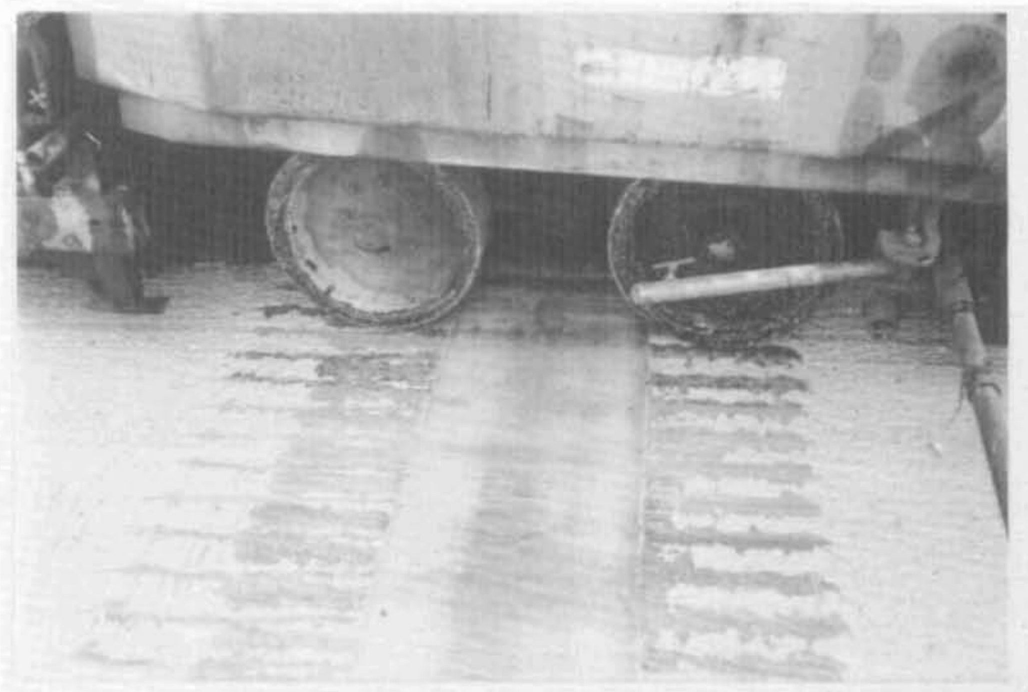


Figure 16 Tack Accumulated on the Wheels of the Paving Machine.

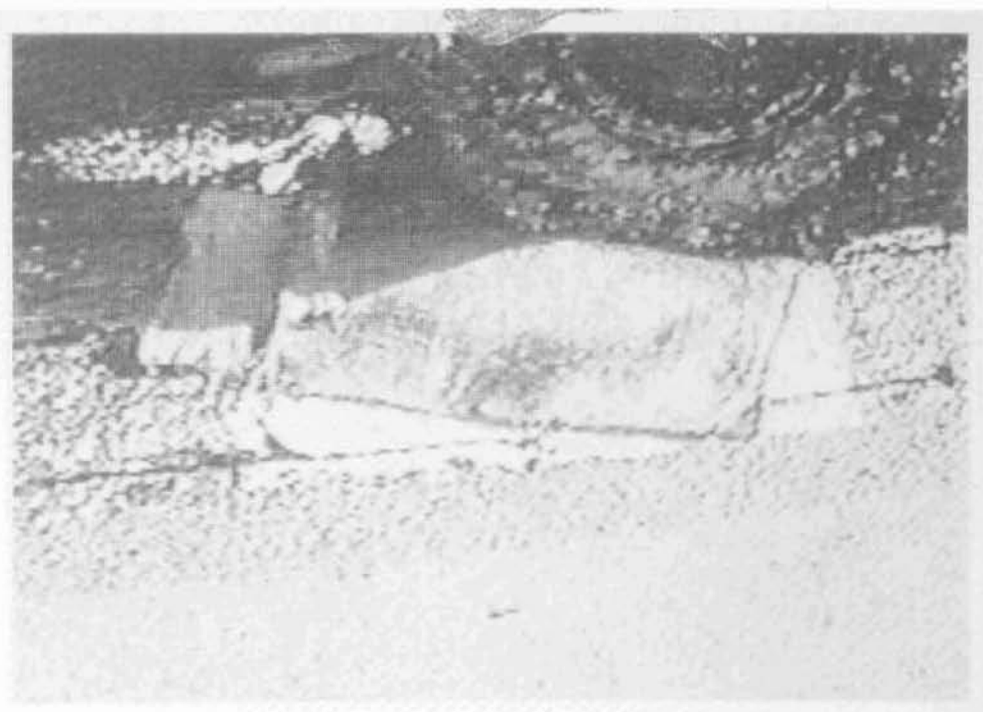


Figure 17 Paveprep Picked Up on the Wheels of Paving Machine.

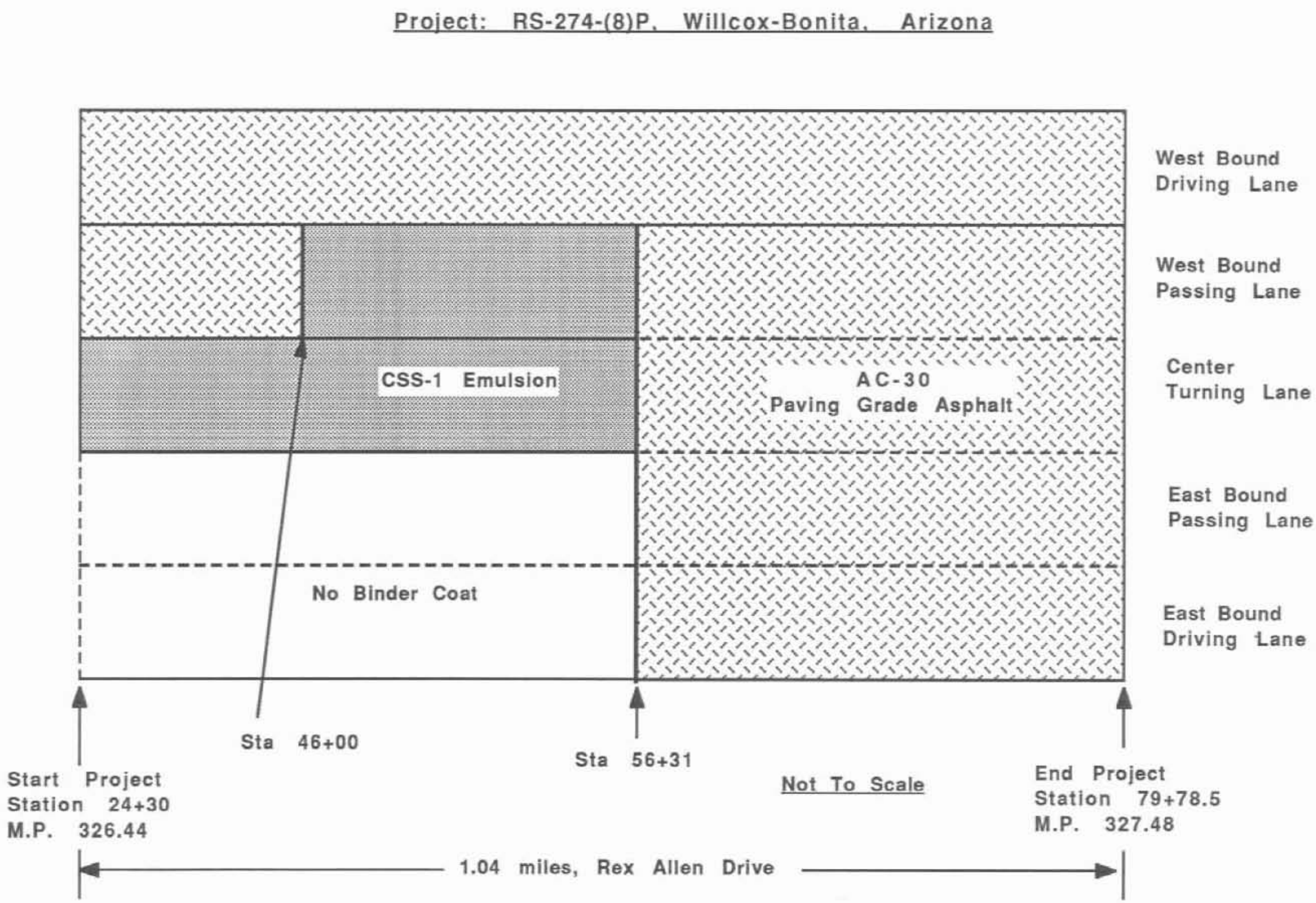


Figure 18 Location of Binder Coats.

Problems with installing the Paveprep continued. The fabric continued to slide under tires due to the improper application of the AC-30 tack. Many different quantities of AC-30 were tried, but a good bond could not be attained. Hot asphalt concrete was spread over the fabric to reduce the stress of the tires passing over it, but there was still no evidence of a bond with the existing surface. Even after setting for two hours, the fabric was still picked by the paving machine. The paving ski's metal plates caught the edge of the fabric and rolled it up.

During the later stages of construction it was decided to not use any binder coat for the overlay (see Figure 18 for locations) in hopes of keeping the paving machine from picking up the fabric. This proved to be no solution as the Paveprep installations continued to pull up under construction traffic.

Glassgrid

Eight transverse cracks, crossing 470 ft. of roadway, and 146 ft. of random cracking were treated with Glassgrid. Glassgrid is self-adhering, and installation consisted of cutting, laying, and rolling the fabric. A pickup truck with dual tires was used to roll the fabric. Figure 19 is a photograph of Glassgrid placed on a transverse crack.

Figure 19 Glassgrid Installed on a Transverse Crack.

The Glassgrid did not bond well to the existing surface. The boot truck, belly dump, and paving machine all pulled up the paving fabric. The bond was poorer than with the Paveprep, and in some instances the fabric was pulled completely off of the surface. Just a small amount of asphalt cement would cause the fabric to be picked up. Hot asphalt concrete was spread under equipment tires in an attempt to keep the fabric from being picked up, but this did little to help.

The bonding problem was thought to be a result of Glassgrid's mesh structure. Because of this structure there is limited surface area in contact with the existing surface. A milled surface amplifies this limit. Even after the binder coat was changed from AC-30 to emulsion, the fabric still picked up. Better results came from completely eliminating the tack coat, as shown in Figure 20. In an attempt to increase the bond, a pneumatic roller was employed rather than a pickup truck to roll the fabric. However, no bonding improvement was noticed.

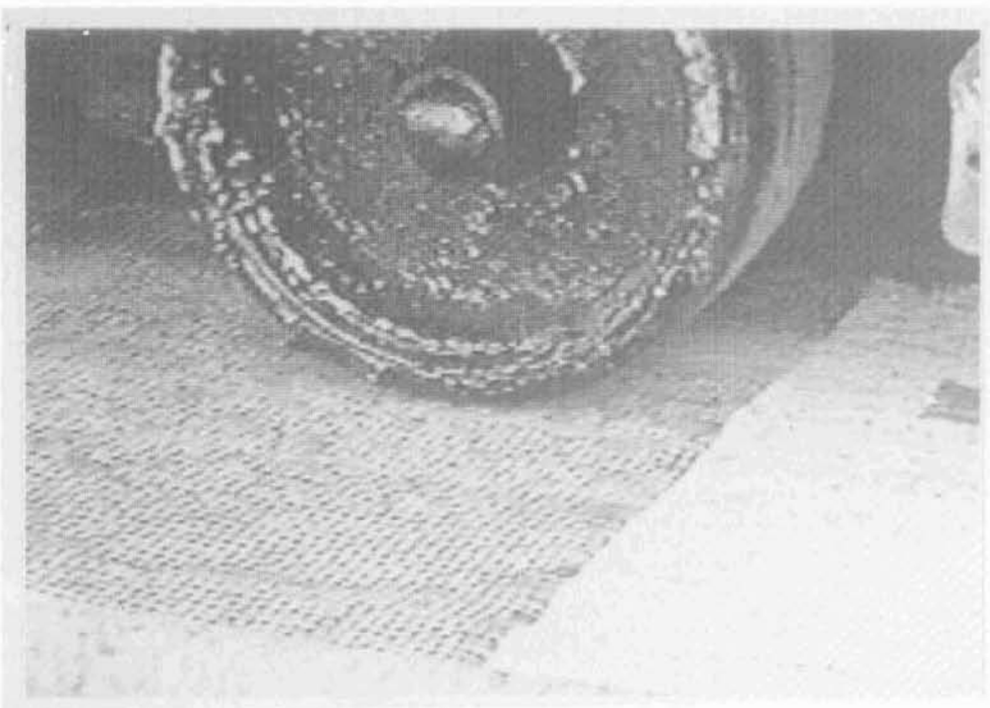


Figure 20 Glassgrid Placed Without Binder Coat.

Tapecoat

Eight transverse cracks, crossing 472 ft. of roadway, were treated with 12 in. wide Tapecoat. Also, 93 ft. of random cracks were treated with 4 in. wide Tapecoat, and 52 ft. of random cracks were treated with 12 in. wide Tapecoat. Refer to Figure 3 for locations. Like Glassgrid, Tapecoat is self-adhering, and as such the installation required cutting the material, peeling off the backing to expose the adhesive surface, and rolling the placed fabric. A pickup with dual wheels was used to roll the fabric. Figures 21 and 22 show 12 in. and 4 in. Tapecoat installations.

Figure 21 12-in. Tapecoat Placed on a Transverse Crack.

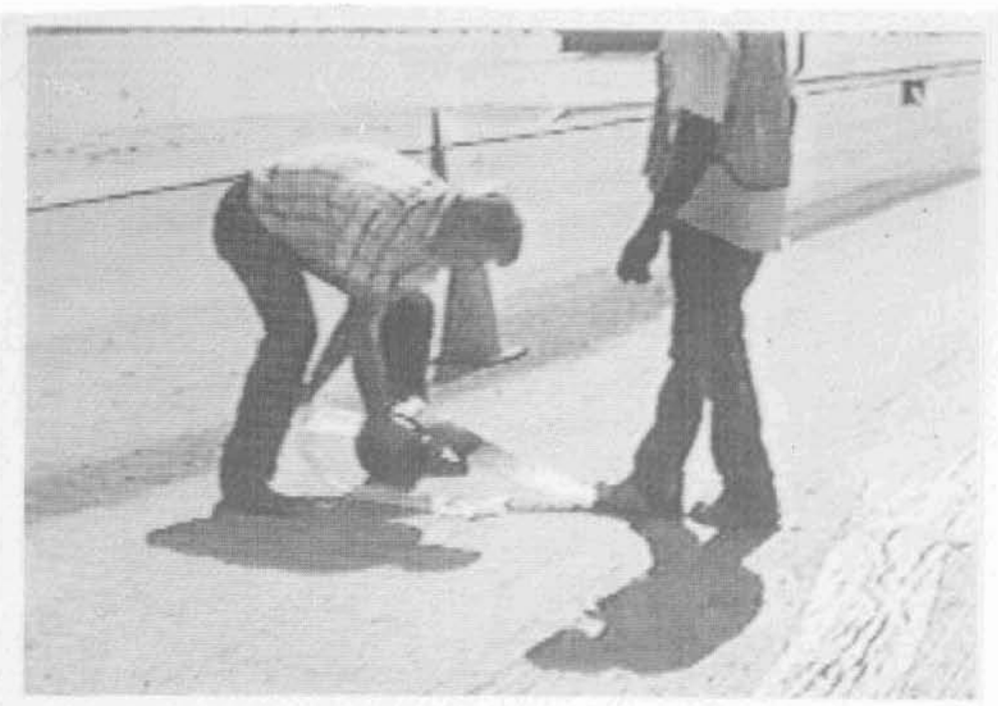


Figure 22 4-in. Tapecoat Placed on Random Cracking.

As with the other fabrics, the Tapecoat curled up beneath the tires of construction equipment that had AC-30 tack built up on their tires. The problem occurred with less frequency than with either the Paveprep or the Glassgrid, and upon changing the AC-30 binder coat to emulsion the Tapecoat no longer picked up under tires.

Travira Spunbound

On the east side of the construction project, from stations 56+61 to79+78, a pavement reinforcing fabric called Travira Spunbound was used. The fabric was laid covering the full width of the roadway for the full length of the remainder of the project. The fabric meets ADOT specifications, and is not considered a part of the test section, however, it's performance was also informally monitored.

For the installation of the Travira Spunbound, a tack coat of AC-30 was placed on the existing milled surface at a rate of 0.3 gal./sq. yd.. The fabric was then placed using a fabric installer that was attached to the loader bucket of a backhoe. Figure 23 is a photo of the fabric being placed on the milled surface. The tack coat was applied in 12 ft. lanes and placed 6 in. wider than the fabric. Then the fabric was placed 6 in. wider than the overlay paving passes (i.e. the fabric overlapped into the adjoining lane(s)). The beginning and ends of the rolls were overlapped 1 ft. and tacked. Wrinkles in the Travira Spunbound greater than 0.5 in. high were cut and the material pulled so that it overlapped.

Figure 23 Placement of the Travira Spunbound Fabric.

HMAC Overlay

The overlay was a 2-in. thick, 0.5-in dense graded hot mix asphalt concrete. Paving was done with a Barber Greene Paving Machine with a KoCal pickup. The paving machine is shown in Figure 24. The asphalt concrete was mixed and hauled from Tucson using belly dump trucks, with the average time of transit being 45 minutes.

Figure 24 The Barber Greene Paving Machine.

Paving began on August 8, 1988, and started on the west bound driving lane at the east end of the project (sta. 79+78). Figure 25 depicts the entire paving sequence in terms of daily starting and ending locations. Based on these starting and ending points, the daily production rates were estimated as follows: 1.44 miles on the first day (Aug. 8), 1.53 miles on the second day (Aug. 9), 1.55 miles on the third day (Aug. 10), and 0.68 miles on the last day (Aug. 11).

Compaction of the overlay was achieved by the use of three rollers. First a vibratory steel roller made three passes. Next a pneumatic roller made two passes. And finally, a second steel roller performed the finish rolling. Figure 26 shows the vibratory steel roller, and Figure 27 illustrates the pneumatic roller used on this project.

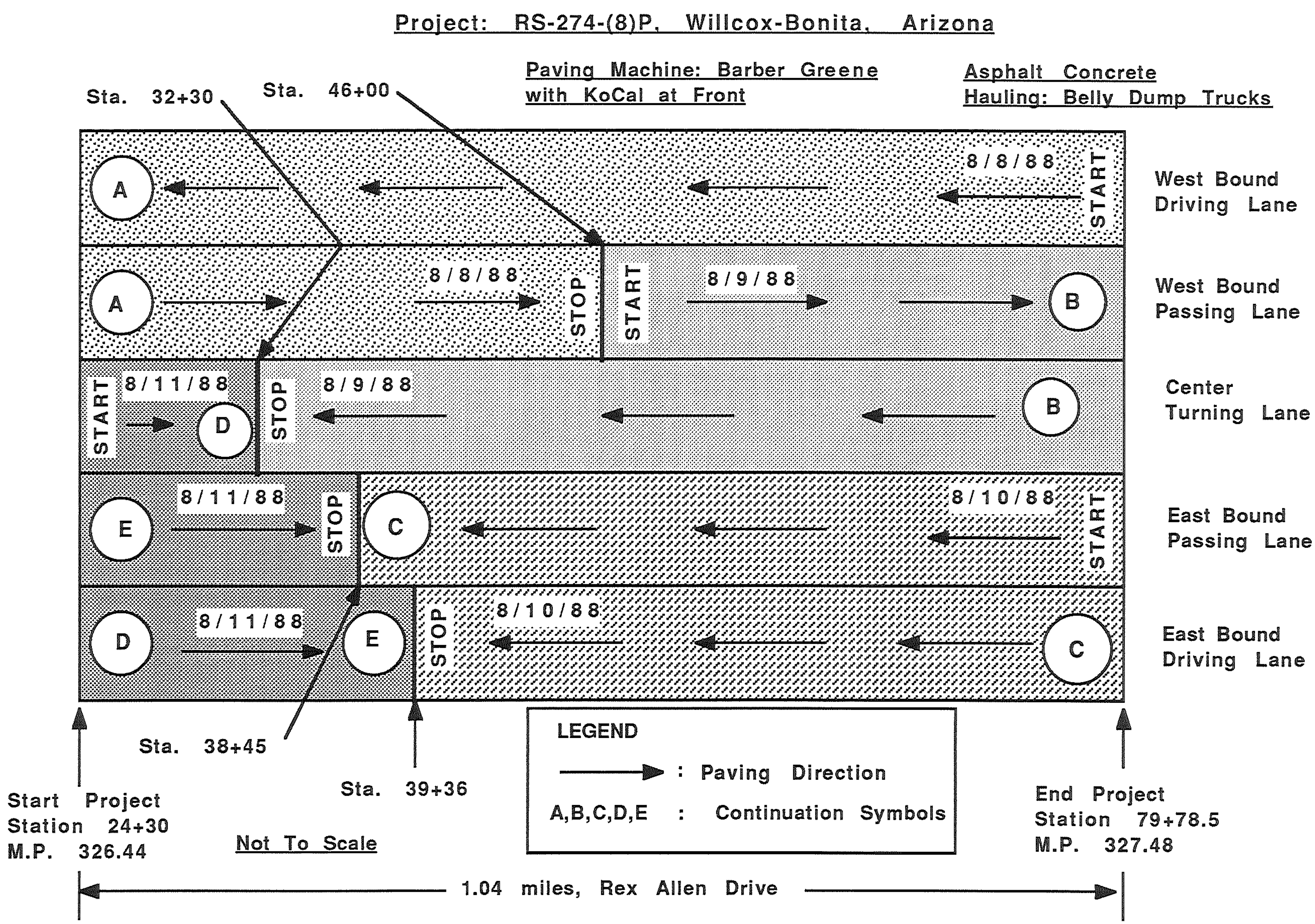


Figure 25 Paving Sequence.

Figure 26 Vibratory Steel Roller.

Figure 27 Pneumatic Roller.

Paving Conditions

Table 2 presents the temperature of the asphalt concrete in relation to the date and location it was placed. The information is illustrated in Figure 28. Daily weather conditions during construction are presented in Table 3.

Lot #	Date	Asphalt Concrete Temperature (°F)	Location	Roadway Lane
1	8/8/88	300	29+80 to 27+50	WB DL
1	8/8/88	298	33+50 to 35+10	WB PL
1	8/8/88	280	39+25 to 40+50	WB PL
1	8/8/88	285	43+90 to 45+25	WB PL
2	8/9/88	240	47+75 to 48+90	WB PL
2	8/9/88	270	48+90 to 50+20	WB PL
2	8/9/88	275	61+00 to 62+90	WB PL
2	8/9/88	285	79+79 to 77+40	CTL
2	8/9/88	280	64+40 to 62+60	CTL
2	8/9/88	280	55+50 to 53+85	CTL
2	8/9/88	270	60+90 to 59+50	CTL
2	8/9/88	276	50+10 to 48+85	CTL
2	8/9/88	278	44+15 to 42+80	CTL
3	8/10/88	274	65+50 to 66+75	EB DL
3	8/10/88	280	71+10 to 73+15	EB DL
3	8/10/88	281	71+15 to 69+00	EB PL
3	8/10/88	280	60+00 to 58+60	EB PL
3	8/10/88	282	50+80 to 49+10	EB PL
3	8/10/88	279	43+00 to 41+35	EB PL
3	8/10/88	286	55+20 to 53+50	EB DL
3	8/10/88	276	46+40 to 44+50	EB DL
4	8/11/88	280	24+30 to 25+40	CTL
4	8/11/88	280	32+00 to 30+50	EB PL

WB: West Bound, EB: East Bound, CTL: Center Turning Lane, DL: Driving Lane. PL: Passing Lane.

Table 2 Asphalt Concrete Placement Temperatures.

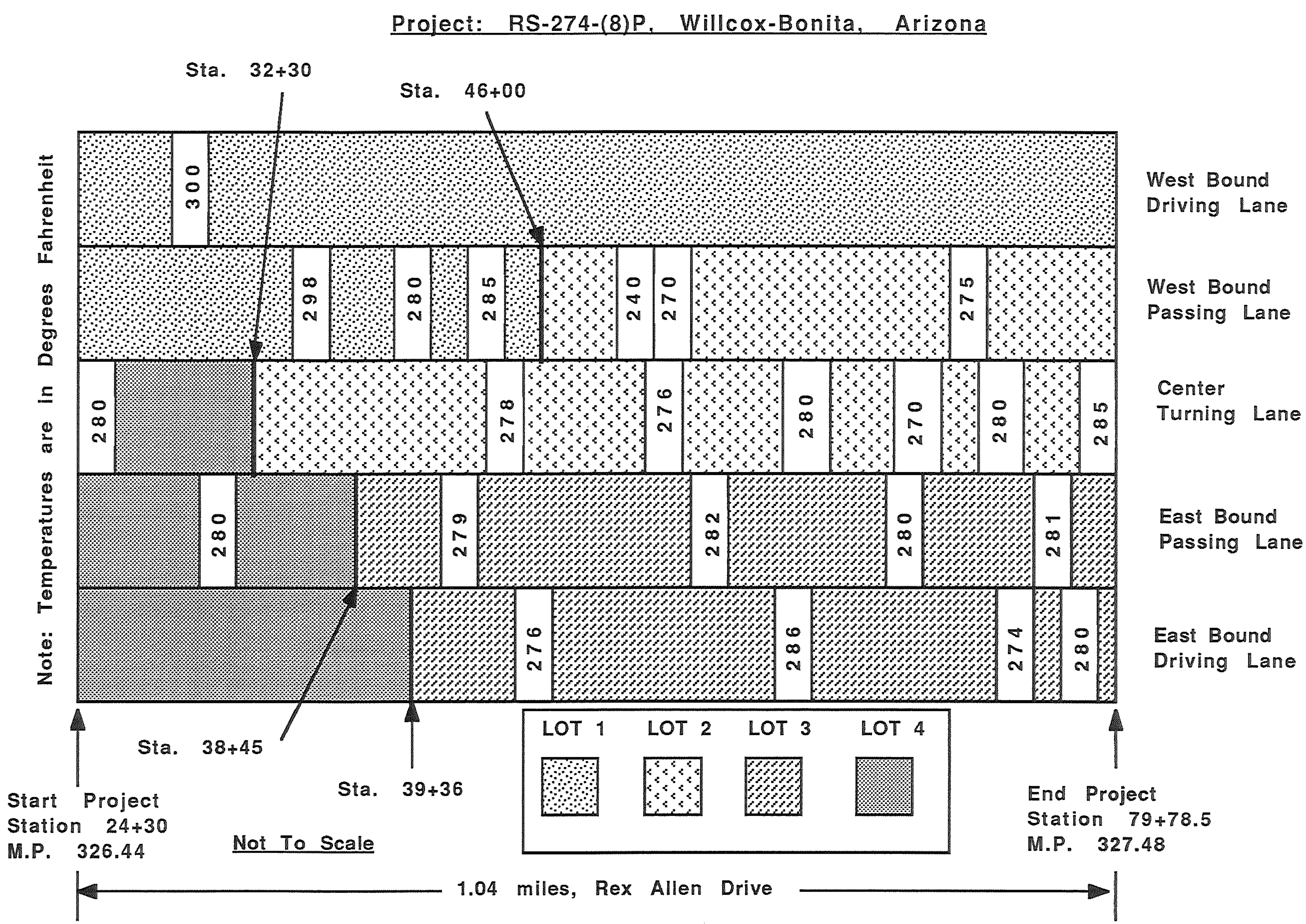


Figure 28 Asphalt Concrete Placement Temperatures.

Date	Project Activity	Weather
8/1/88	Milling & Pickup Broom	Warm & Cloudy
8/2/88	Milling & Brooming in Rain	Cloudy, Rain at 9:30
8/3/88	Milling & Pickup Broom	Cool, Heavy Clouds
8/4/88	Milling & Brooming	Cloudy, Rain Last Night
8/5/88	Milling & Brooming	n/a
8/8/88	Fabric Placement & Paving	Hot & Partly Cloudy
8/9/88	Fabric Placement & Paving	Hot & Partly Cloudy
8/10/88	Fabric Placement & Paving	Hot & Partly Cloudy
8/11/88	Fabric Placement & Paving	Hot & Partly Cloudy

Table 3 Weather Conditions During Construction.

Construction Notes

On the first day of paving (Aug. 8), the three transverse cracks identified as 1A, 1B, and 1C were overlaid without paving fabric on the westbound driving and passing lanes. This has been noted in Figure 3.

On the next day (Aug. 9), a meeting was held at the construction office with the resident engineer to discuss the status of the project. Topics of discussion were focused primarily at the method of cleaning the milled surface, the problems with placing the paving fabrics, and the binder coat problems. The Glassgrid representative expressed concerns about the binder coat used for the overlay. The Paveprep representative was concerned with the low temperature of the AC-30. Based on the concerns presented and the research interests of the project, the resident engineer decided to try a section of roadway without any binder coat (refer to Figure 18).

At the end of the third day of paving (Aug. 10), some of the Paveprep and Tapecoat installations on the eastbound lanes were left exposed to normal traffic. Rather than damaging the fabrics, the overnight traffic helped to increase the bond of the fabrics with the milled pavement surface.

The ATRC made several video tapes of the inspection and construction of the project. These tapes were later combined to produce a final video showing the construction of the experimental project. The videos are stored at the ATRC library and are identified in Table 4.

Video #	Description
31	Field Inspection, 9/15/87
51	Milling, 8/1 and 8/2/88; Fabric Installation & Paving, 8/8 and 8/9/88
52	Fabric Installation & Paving, 8/9 thru 8/11/88
55	Rex Allen Drive, Final Production

Table 4 Identification Numbers of ATRC Video Tapes of The Project.

MATERIAL CHARACTERISTICS

General

The mix design criteria for the asphalt concrete used for the Rex Allen Drive project as specified is listed in Table 5. Table 6 lists the specifications for the mix design grading limits, and Table 7 is the specifications for the mineral aggregate characteristics. Table 8 is the criteria for verification testing. All of the information in Tables 5 through 8 is based on 1987 ADOT Standard Specifications and the Special Provisions of this project.

Test Results

ADOT's Materials section and a private lab conducted the asphalt concrete mix design verification. Data obtained from these tests are presented in APPENDIX E. All of the lots except for one were within the specifications for asphalt concrete density. Table 9 is the log used for asphalt concrete acceptance testing. Figure 29 gives the locations of the samples used for acceptance testing. Table 10 is the materials log for acceptance testing. No tests were performed on the paving fabrics to verify the strength standards claimed by their manufacturers.

Criteria	Requirements (1/2" Mix)	Arizona Test Method
Voids in Mineral Aggregate, %, Range	15.5 - 18.5	815
Effective Voids, %, Range	6.0 ± 0.2	815
Index of Retained Strength %, Minimum	50	802
Wet Strength, psi, Minimum	150	802
Stability, Pounds, Minimum	2000	815
Flow, 0.01 inch, Range	8-16	815
Adsorbed Asphalt, %, Range	0-1.0	815

Table 5 Mix Design Criteria[6].

Sieve Size	Percent Passing, Mineral Aggregate 1/2 inch Mix, With Admixture
3/4 inch	100
1/2 inch	90 - 100
3/8 inch	70 - 85
No. 8	44 - 52
No. 40	13 -23
No. 200	3.0 - 7.5

Table 6 Mix Design Grading Limits[7].

Characteristic	Test Method	Requirement
Combined Bulk Specific Gravity	AASHTO T 85 AZ Test Method 211	2.35 - 2.85
Combined Water Absorption	AASHTO T 85 AZ Test Method 211	0.00 - 2.50
Sand Equivalent	AASHTO T 176	Minimum 45
Crushed Faces	AZ Test Method 212	Minimum 30%
Abrasion	AASHTO T 96	100 Rev., Max 9% 500 Rev., Max 40%

Note: Abrasion shall be performed separately on samples from each source of mineral aggregate. All sources shall meet the requirements for abrasion.

Table 7 Mineral Aggregate Characteristics[8].

Property	Allowable Deviation From Proposed Targets	Limiting Values
Sand Equivalent	-10	45 Min.
Crushed Faces, %		30 Min.
Abrasion: 100 Rev.		9 Max.
500 Rev.		40 Max.
VMA, %	+1.5	14.5 Min.
Effective Voids, %	+1.0	
Stability, Pounds		1,750 Min.
Flow, 0.01 inch		7 - 17
Index of Retained Strength, %		45 Min.
Wet Strength, psi		140 Min.

Table 8 Verification Testing Criteria[9].

SN	LN	1/2 inch Asphalt Concrete Mix Design Data											
		3/4"	1/2"	3/8"	#4	#8	#40	#200	Asph	VMA	EV	VF	BD
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1	1	100	93	83	64	49	17	2.8	5.3	15.6	5.2	66.9	142.7
2	1	-	-	-	-	-	-	-	-	-	-	-	141.9
3	1	100	95	87	67	50	15	1.9	5.6	17.3	6.5	62.3	140.2
4	2	100	90	78	55	42	15	2.9	4.9	14.8	5.2	64.8	143.9
5	2	-	-	-	-	-	-	-	-	-	-	-	142.4
6	2	100	89	76	54	41	14	2.1	5.2	15.8	4.2	73.4	142.4
7	3	100	93	81	63	47	16	3.6	5.6	15.7	3.9	74.2	143.9
8	3	-	-	-	-	-	-	-	-	-	-	-	144.2
9	3	100	94	83	62	47	17	3.5	5.1	15.2	5.2	66.0	143.2
10	4	100	94	84	66	49	18	3.7	5.5	15.1	4.2	72	143.8
11	4	-	-	-	-	-	-	-	-	-	-	-	143.5
12	4	100	92	81	61	45	15	1.3	5.3	15.2	4.8	68.1	143.4
Average		100	93	82	61	46	16	2.7	5.3	15.6	4.9	68.5	142.9
Standard Dev.		0	2	3	5	3	1	0.9	0.3	0.8	0.8	4.3	1.1

SN: Sample No., LN: Lot No., Asph: % Asphalt, VMA: % Voids in Mineral Aggregate,
EV: Effective Voids, VF: % Voids Filled with Asphalt, BD: Bulk Density in pcf,
Note: Columns 3 through 9 are aggregate gradation data, % passing through different sieve sizes.

Table 9 Asphalt Concrete Log for Acceptance Testing.

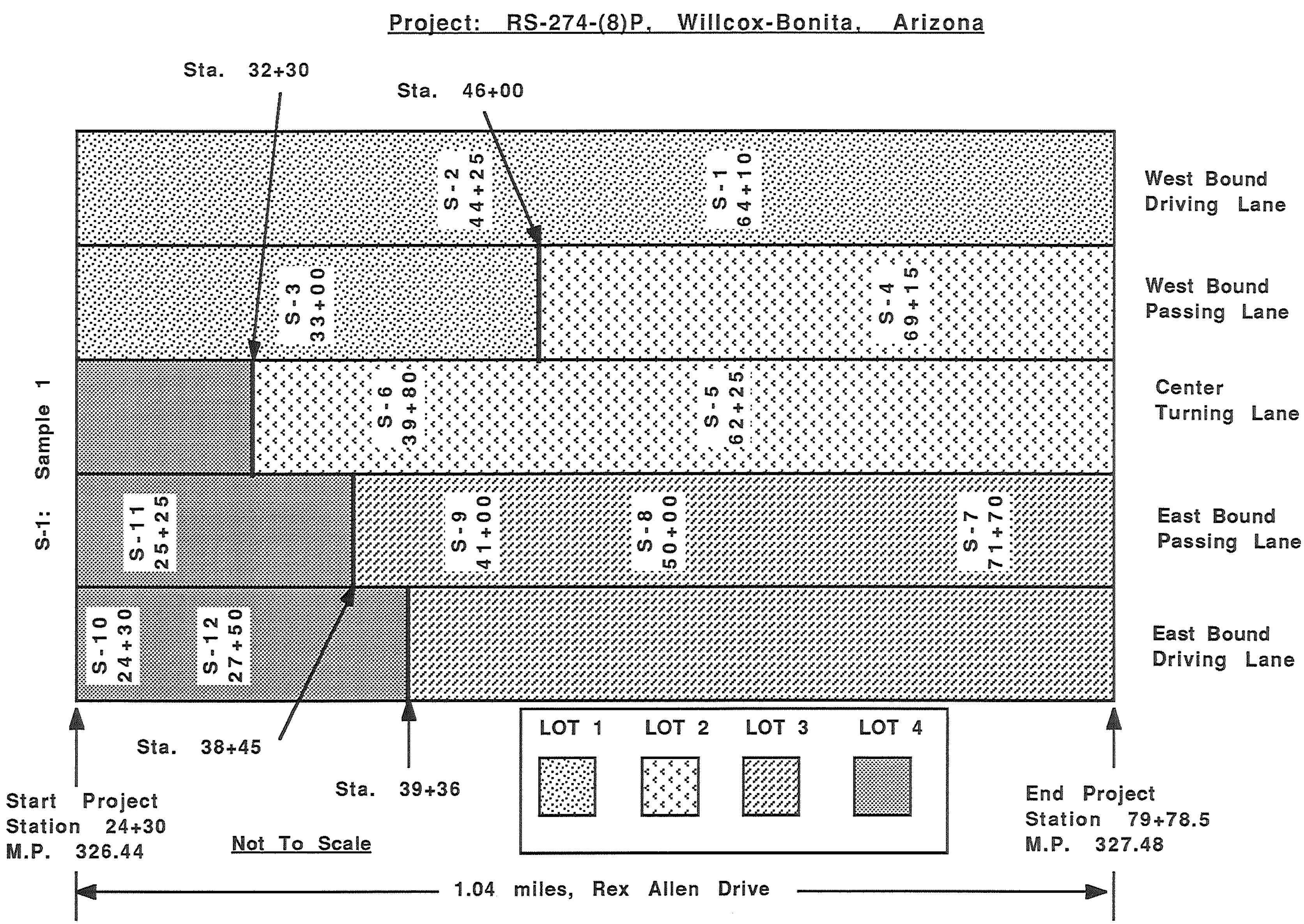


Figure 29 Sampling Locations for Acceptance Testing.

SN	Sampled From	MA Gradation, 1/2" Mix, 1% Admx, % Passing						SE	FFC
		3/4"	1/2"	3/8"	#8	#40	#200		
1	CFB	100	92	82	48	15	2.5	-	-
2	CFB	100	91	82	47	14	2.6	-	-
3	CFB	100	92	81	46	15	2.5	-	-
4	CFB	100	91	81	48	15	2.9	-	-
5	CFB	100	91	81	47	16	2.8	-	-
6	CFB	100	91	80	45	14	3.1	-	-
7	CFB	100	92	83	49	16	3.2	-	-
8	CFB	100	92	82	47	15	2.8	-	-
9	CFB	100	91	81	49	18	3.3	-	-
1	SP(CP)	-	-	-	-	-	-	73	80
2	SP(CP)	-	-	-	-	-	-	74	81
3	SP(CP)	-	-	-	-	-	-	57	40
AVG		100	91	81	47	15	2.9	68	67
SD		0	0.5	0.9	1.3	1.2	0.3	9.5	23.4
SPEC		100	87-99	67-88	42-54	11-25	2.5-8.0	>=45	>=30

SN: Sample No., CFB: Cold Feed Belt, SP: Stock Piles, CP: Calmat Pit,
GP: Granite Pit, SE: Sand Equivalent, FFC: Crushed Faces, AVG: Average,
SD: Standard Deviation, SPEC: Arizona Specifications,
MA: Mineral Aggregates, Admx: Mineral Admixtures.

Table 10 Materials Log for Acceptance Testing.

EVALUATION

First Field Evaluation

On April 11, 1989, the ATRC performed it's first field evaluation of the paving fabrics experimental project. The location of the original pavement's cracks were identified, and these areas were inspected for reflective cracking. Crack lengths were measured on the supposition that they might be an indicator as to how well the fabrics prevent reflective cracking. Also, in the interest of the fabrics' ability to mitigate the propagation of reflective cracking, the widths of the cracks were recorded by severity. Zero to .25 in. wide cracks were considered low severity, .25 to .50 in. cracks were medium severity, and cracks of width greater than .50 in were considered high severity.

The raw data, presented in an office prepared table, and results from statistical analyses using the software package SPSS are included as APPENDIX F. A synopsis of the analyses follows:

> A total of 488 ft. of high severity transverse cracks were treated with Paveprep, 481 ft. of cracks with Glassgrid, 473 ft. with Tapecoat, and 483 ft. of high severity transverse cracks were left untreated to be used as the control.
>
> The average percent of transverse crack length which reflected through to the surface for the entire 32 crack population was 69.9% with a standard deviation of 32.4%.
>
> Of the 8 cracks under consideration that were treated with Paveprep (Treatment A), the average percent of each transverse crack length reflected through to the surface was 73.6% with a standard deviation of 29.5%.
>
> Of the 8 cracks that were treated with Glassgrid (Treatment B), the average percent of each transverse crack length reflected through to the surface was 58.3% with a standard deviation of 40.0%.
>
> Of the 8 cracks that were treated with Tapecoat (Treatment C), the average percent of each transverse crack length reflected through to the surface was 63.3% with a standard deviation of 30.5%.
>
> Of the 8 cracks that were untreated and used as a control (Treatment D), the average percent of each transverse crack length reflected through to the surface was 84.6% with a standard deviation of 28.1%.

Statistical comparisons were made based on this information with the average percentages taken as the response variable. All tests were performed at a 95% confidence interval. The results are listed below:

> The results of an Analysis of Variance (ANOVA), indicated that there was no statistical evidence that any one of the Treatments was performing better than the others.

In support of the ANOVA results, Duncan's Multiple Range test indicated that there was no statistically significant difference in any two of the means of each of the Treatments.

A t-test was performed between each of the products and the untreated control. The results concurred with the previous tests in that there was no statistical evidence that any of the paving fabrics were performing any better than the untreated control in the prevention of reflective crack propagation.

The performance of the monitored treatments at the time of this first field evaluation is summarized in Table 11.

Product	% Reflected By Number of Cracks	Observed Crack Length (Total, L. ft.)	% Reflected By Total Crack Length	Severity
Paveprep	100	371	76	Low
Glassgrid	87.5	291	60	Low
Tapecoat	100	300	63	Low
Control	100	409	85	Low

Table 11 Summary of Product Performance; Field Evaluation #1, April 11, 1989.

Observations of crack severity yielded no apparent difference in any of the treatments in comparison to the control. All of the paving fabrics appeared to be equally ineffective in preventing or mitigating reflective cracking at this location, based on comparisons with the untreated cracks.

Observations were made in the random and longitudinal crack treatment areas. The 28 ft. long longitudinal crack treated with Paveprep (refer to Figure 3) showed no sign of reflective cracking. The other Paveprep treated random cracking area between Arizona Ave. and Mesa Ave. was not evaluated. The Tapecoat treated area between Bowie Ave. and Arizona Ave. showed approximately 32 ft. out of a potential 216 ft. reflective cracking. The Glassgrid treated area between Cochise Ave. and Bowie Ave. showed no apparent reflective cracking.

The evaluation of the Travira Spunbound section was performed by counting the number of transverse cracks east of the experimental project through the end of the construction project. The cracks were recorded per tenth of a mile, beginning just east of the experimental project crack identified as 7D. Travelling east, there were 8 full width transverse cracks in the first tenth mile, 8 cracks in the second tenth, 9 cracks in the third tenth, 6 cracks in the fourth tenth, and 0 full width transverse cracks in the fifth tenth of a mile. All cracks were low severity.

Second Field Evaluation

The second and final field evaluation of the paving fabric experimental project was performed by ATRC personnel on May 28 and 29, 1991. Consistent with the first evaluation, the location of the original cracks in the pavement surface were identified and inspected for reflective cracking. Crack lengths were measured on the supposition that they might be an indicator as to how effective the fabrics were in preventing reflective cracking. Also, in the interest of determining the fabrics' ability to mitigate the propagation of reflective cracking, the widths of the cracks were recorded in terms of severity. Cracks of 0 to .25 in. were called low severity, those cracks of .25 to .50 in. were called medium severity, and cracks of greater than .50 in. were designated high severity.

The raw data of the field inspection, presented in an office prepared table, and the results from statistical analyses using the software package SPSS are included as APPENDIX G. It needs to be noted that for all of the statistical analyses included in the second evaluation that one of the Paveprep treated cracks was ignored. Station 24+30, where the first Paveprep treated crack is located, was also the beginning station of the construction project. Visual observation indicated there may be varying pavement thicknesses at this location. There were no cracks visible on the surface, which was extremely inconsistent with the other Paveprep installations, and less than the 8 ft. of cracking recorded during the first field evaluation. As such, it is felt that there were other factors affecting the propagation of cracks in this area, and that the data from this location would have been misleading.

Statistical analyses, with crack 1A removed from the data, results in the following:

> A total of 420 lineal feet across the roadway of high severity transverse cracks were treated with Paveprep, 470 lineal feet across with Glassgrid, 472 lineal feet across with Tapecoat, and 480 lineal feet across the street were left untreated.
>
> The average percent of transverse crack length which reflected through to the surface for all of the 31 cracks included in the evaluation was 96.87% with a standard deviation of 7.22%.
>
> Of the 7 cracks under consideration that were treated with Paveprep (Treatment A), the average percent of each transverse crack length reflected through to the surface was 98.29% with a standard deviation of 4.54%.
>
> Of the 8 cracks that were treated with Glassgrid (Treatment B), the average percent of each transverse crack length reflected through to the surface was 96.00% with a standard deviation of 10.53%.
>
> Of the 8 cracks that were treated with Tapecoat (Treatment C), the average percent of each transverse crack length reflected through to the surface was 94.00% with a standard deviation of 8.50%.

Of the 8 cracks that were used as the control and untreated (Treatment D), the average percent of each transverse crack length reflected through to the surface was 99.38% with a standard deviation of 1.77%.

Statistical comparisons were made based on this information with the average percentages of crack length reflecting through the overlay taken as the response variable. All tests were performed at a 95% confidence interval. The results are listed below:

The results of an Analysis of Variance (ANOVA) indicated that there was no statistical evidence that any of the Treatments had performed any better that the others.

In support of the ANOVA results, Duncan's Multiple Range test indicated that there was no statistically significant difference in any two of the means of each of the Treatments.

A t-test was performed between each of the products with the untreated control. The results concurred with the previous tests in that there was no statistical evidence that any of the paving fabrics had performed any better than the untreated control in the prevention of reflective crack propagation.

The performance of the monitored treatments, with crack 1A ignored, at the time of the second field evaluation is summarized in Table 12.

Product	% Reflected By Number of Cracks	Observed Crack Length (Total, L. ft.)	% Reflected By Total Crack Length	Severity Range
Paveprep	100	413	98	(L) to (M)
Glassgrid	100	454	97	(L) to (M)
Tapecoat	100	444	94	(L) to (M to H)
Control	100	477	99	(L to M) to (M)

Table 12 Summary of Product Performance; Field Evaluation #2, May 29, 1991.

Observations of crack severity yielded no significant difference in any of the treatments in comparison to the control. All of the paving fabrics appeared to be equally ineffective in preventing or mitigating reflective cracking at this location, based on comparisons with the untreated cracks.

Observations were made in the vicinities of the random and longitudinal cracks treated with Paveprep, Glassgrid, and Tapecoat. The area of paving fabric treatments contained a significant number of cracks. However, due to imprecision in documenting the exact location of the treated random cracks, it is uncertain if these cracks propagated through the fabric and the AC overlay to the surface.

The evaluation of the Travira Spunbound section was performed by counting the number of transverse cracks east of the experimental project through the end of the construction project. The cracks were recorded per tenth of a mile, beginning just east of the experimental project crack identified as 7D. Travelling east, there were 4 full width transverse cracks counted in the first tenth mile, 3 cracks in the second tenth, 5 cracks in the third, and 1 full width transverse crack in the fourth tenth of mile. Cracks in the fifth tenth mile were not counted. Additionally, the number of transverse cracks which fully crossed the center turning lane of the road were counted. Once again travelling east, there were 12 transverse cracks across the center lane in the first tenth mile, 15 in the second, 14 in the third, and 7 transverse cracks across the entire turning lane in the fourth tenth mile.

Core Samples

Core samples were taken to verify that the cracks visible on the surface of the experimental project were reflective cracks, and had propagated from the original pavement through the paving fabric and overlay. The Operating Characteristic method (OC-method) of obtaining a single sampling plan was used to develop acceptance and rejection standards for the core samples. The OC-method is presented in Chapter 5 of Applied Statistical Techniques by Stoodley, Lewis, and Stainton[10]. A detailed description of the assumptions made and the procedures followed in developing the sampling plan are included as APPENDIX H.

The sampling plan was formulated to confirm or deny the validity of the evaluation of the surface cracks as they related to the performance of the paving fabrics. To clarify the sampling plan procedure, four definitions will be used in this report. Acceptance of the sample meant that a significant proportion of the cracks were reflective and passed through the fabric. This in turn meant that the conclusions drawn from the evaluation of the surface cracks were applicable to the performance of the paving fabrics. Rejection of the sample meant that the cracks could not be said to be reflective and/or did not pass through the paving fabrics. In the rejection case, no conclusions could be drawn as to the performance of the paving fabrics based on the evaluation of the surface cracks. An individual core sample with the reflective cracking was said to be positive. An individual core sample in which either the crack had not propagated from the original surface, OR, for which the fabric was not in place was said to be negative.

The results of the OC-method calculations of APPENDIX H led to a positive sample limit to total sample ratio of 0.6282. In other words, greater than 62.8% of the sample number would have to be negative in order to reject the entire project. The sample size was limited primarily by the time involved in taking the core samples. Therefore, a core sample procedure for the experimental project was created based on the OC procedure. The procedure provided for two cracks of each of the three fabrics and the control to be sampled. The core samples have to be taken discreetly, so, had one of the two samples proved to be positive (i.e. showing reflective cracking through the paving fabric), that would have been sufficient to accept all of the cracks of that particular treatment. The same is the case if both of the samples were positive. However, if both of the samples proved to be negative (i.e. either showing that the crack was not reflective or that it did not pass through the fabric), all of the cracks of that particular treatment would be rejected.

Because of the small sample size, rejection of the cracks of a particular treatment could only be rationalized under this method if 100% of the 2 core samples were negative. Because of this, plans to increase the confidence of the core sampling were made in advance. Had both of the samples been positive, the test was completed and the entire population was judged acceptable. Had neither or only one of the samples proved to be positive, plans were made to then take two additional cores from cracks of that treatment. Now, considering the positive limit ratio of 0.6282, rejection of all of the cracks would require 3 or 4 of the four samples be negative. Negative results for 0, 1, or 2 of the four samples would result in acceptance of that particular treatment.

Important premises made for the plan formulated in APPENDIX H include the following:

1. Considering the fact that all of the cracks for each treatment were similar, it was decided that if 4 or more of the 8 cracks of a particular treatment were reflective cracks passing through the pavement, that would be enough to allow conclusions to be drawn about the performance of the paving fabrics based on evaluation of the surface cracks.

2. If 6 or more of the 8 cracks of a particular treatment were not reflective and passing through the paving fabric, that would be sufficient to determine that no conclusions would be able to be drawn regarding the performance of the paving fabrics based on evaluation of the surface cracks.

As it turned out, each of the core sample cracks was observed to have began in the original pavement and propagated through the paving fabric. As such, only two samples of each treatment were necessary. Figures 30, 31, and 32 demonstrate core samples with Paveprep, Glassgrid, and Tapecoat in place. The results of the core sampling confirmed the validity of the results of the field surface crack evaluations.

Figure 30 Core Sample of Paveprep Treated Crack.

Figure 31 Core Sample of Glassgrid Treated Crack.

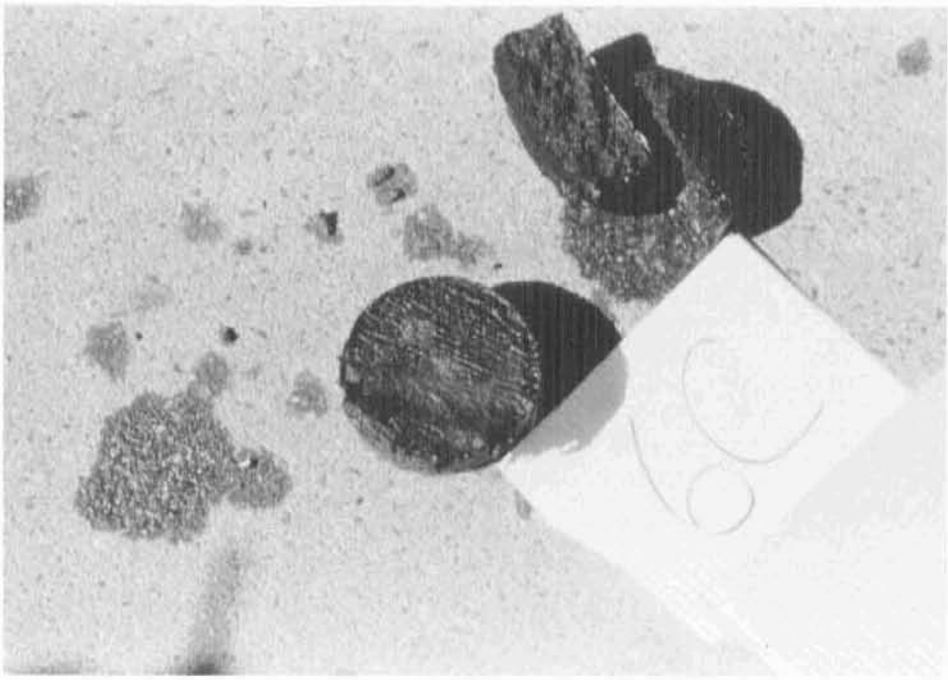


Figure 32 Core Sample of Tapecoat Treated Crack.

Mode of Failure

From the core samples, it was observed that the fabrics had remained intact over the cracks, and showed no sign of distress. This is reasonable as the moduli of the fabrics were such that they were acting as "strain-relieving" interlayers, rather than "reinforcing" interlayers. Button and Lytton define a reinforcing fabric or grid as one in which the modulus is more than 5 times that of the surrounding asphaltic concrete[11]. The modulus of Glassgrid is reported to be 10,000 psi. The manufacturers of Paveprep and Tapecoat did not provide the moduli of their product, but it is apparent that they are much less than that of the AC at this location. Previous laboratory tests have shown three distinct modes of failure for fabric and grid treated overlay samples. These are illustrated in Figure 33.

Failure modes I and III occur when the material acts as a "strain-relieving" layer. This is consistent with the results obtained from this experimental project. The fabrics elastically stretched to accommodate the propagation of the crack. It is unknown whether the crack propagated up from the fabric to the surface, or down from the surface to the fabric.

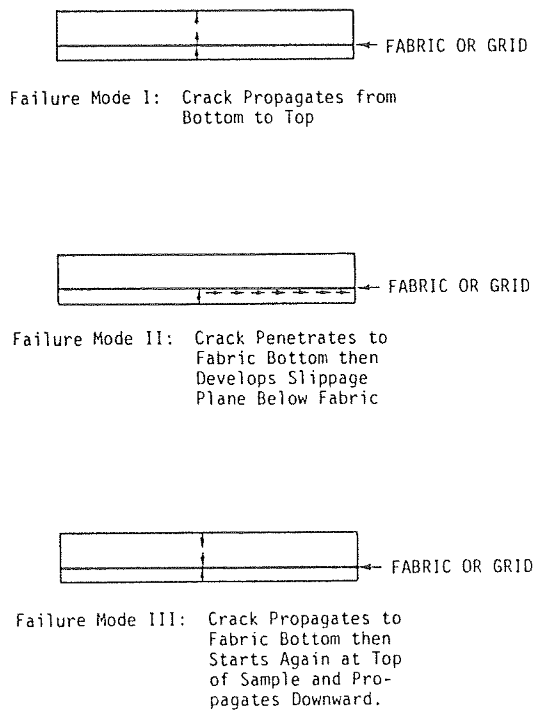


Figure 33 Modes of Fabric and Grid Treated Sample Failure[11].

Field Evaluation Notes

The means of recording crack length was changed between field evaluations. Apparently during the first field evaluation, the actual length of the crack was measured and recorded. This length included any side to side variations in the crack. This distance was compared with an assumed original crack length, which was at times greater than the width of the street. For the second field evaluation, only the distance perpendicularly across the street of the cracks was recorded. This was done because there was no means of verifying the actual crack length before the overlay was placed. Also, the configuration of the crack was not initially determined. Measuring across the street yields a base distance that has remained constant since the construction of the original pavement and curb and gutter, and this base distance will remain the same for some time to come.

Photographic comparisons of many of the experimental project cracks are included as APPENDIX I. The cracks are labelled corresponding to their number-letter identification as per Figure 3. Photographs labelled (a) were taken during the first field evaluation, while those labelled (b) were taken during the second evaluation. All photos were shot from the north side of the street (i.e. looking south). It should be noted that the photographs were taken at different times of the day.

Future Considerations

For future evaluations, it should be remembered that the stationing used to identify the cracks begin at station 24+30 of the construction project, and then are referenced from measurements taken from the north side of the street on the curb. Figure 3 and the table included in APPENDIX G has the current locations of the test cracks recorded in this manner.

CONCLUSIONS

Construction

There were a number of problems with the installation of the paving fabrics. All three of the fabrics did not bond properly when paving grade asphalt was used as a binder coat. Also, each of the products suffered problems with snagging on the ski of the paving machine.

Problems unique to the installation of Paveprep primarily dealt with the tack coat used to bond the fabric. The distribution of the tack was at times highly variable; too heavy or too light, and not evenly distributed. Also, the tack was not sufficiently hot.

There were problems with the Glassgrid installation. The fabric did not bond well to the milled pavement surface, probably because of the presence of fines and the limited surface area of the adhesive. The fabric was frequently picked up under the tires of construction equipment.

The only problem exclusive to Tapecoat was with covering irregular cracks. The 4 in. wide Tapecoat was not wide enough to cover some of the cracks that were not straight.

Performance

Based on the statistical evaluation presented in the EVALUATION of this report, none of the paving fabrics; Paveprep, Glassgrid, or Tapecoat, showed any evidence of being effective in the prevention or mitigation of reflective cracking at this location in Willcox, Arizona. The fabrics were determined to have remained in place on the cracks by means of the core samples. It was also observed that the cracks on the surface were reflective and propagated directly through the paving fabrics. The fabrics through which the cracks propagated showed no sign of distress.

The results of this experiment show that the use of these paving fabrics, installed in the localized manner as they were, did not have any more value in improving the overlay performance than did doing nothing. Additionally, it is not believed that paving fabrics of any type will prevent or mitigate reflective cracking over pavements with widely spaced transverse cracks due to the thermal properties of asphalt concrete. This concurs with results of previous studies[11].

Localized use of paving fabrics to reduce reflective cracking is not recommended. However, based on the experiences of this experimental project, should an agency desire to conduct it's own application of paving fabrics, the agency should investigate the selection of adhesive and/or binder coat prior to construction. These recommendations are not limited to the paving fabrics discussed in this report.

At the end of 5 years (Aug. 1993), the site will be evaluated again to determine the effects of the paving fabrics on the long term performance of the pavement.

REFERENCES

1. State Highway System Log 1990, ADOT Transportation Planning Division.

2. The University of Arizona, "Arizona Climate, The First Hundred Years", 1985.

3. Chart compiled from data from "Arizona Climate, The First Hundred Years", The University of Arizona, 1985.

4. Chart compiled from data from "Arizona Climate, The First Hundred Years", The University of Arizona, 1985.

5. ADOT Pavement Materials Services, 1990.

6. ADOT 1987 Standard Specifications, Table 406-1, pg. 198, and Special Provisions, Sec. 406, pg. 30.

7. ADOT 1987 Standard Specifications, Table 406-2, pg. 199.

8. ADOT 1987 Standard Specifications, Table 406-3, pg. 200 and Special Provisions, Sec. 406, pg.31.

9. ADOT 1987 Standard Specifications, Table 406-6, pg. 204 and Special Provisions, Sec. 406, pg. 31.

10. Stoodley, K.D.C., Lewis, T., and Stainton, C.L.S., Applied Statistical Techniques, John Wiley and Sons, New York, 1980.

11. Button, Joe W. and Lytton, Robert L. "Evaluation of Fabrics, Fibers, and Grids in Overlays" Proceedings, Sixth International Conference on Structural Design of Asphalt Pavements, The University of Michigan, Ann Arbor, 1987.

APPENDIX A Manufacturer Supplied Brochures on Paving Fabrics

THE PavePrep CORPORATION ™

PavePrep is a unique stress-relief interlayer material consisting of high-density, heavy duty mastic between two layers of rugged polyester fabric. The mastic, rated No. 1 nationally, provided PavePrep with durability, water impermeability and compatibility with the final hot-mix asphalt overlay. The polyester fabrics add to the durability, impart dimensional stability and, above all, confer exceptional flex resistance.

The service advantages of PavePrep include:

- Ease of installation (no special equipment needed) with minimum adhesive requirement
- Minimum traffic disruption (traffic may flow over PavePrep prior to final paving)
- High versatility in end-use application and wide working-temperature range i.e. performance is climate-independent
- Further structural decay of surface or underlying base or structure is arrested.

By substantially prolonging the lifetime of streets, highways and other traveled surfaces, PavePrep has major positive impact on maintenance budgets.

PavePrep's component system with its dual stress-relief and water-proofing mechanism-of-action are shown graphically here.

For detailed product specifications and product line and availability see overleaf.

Pave Prep makes your paving dollars more durable.

Installed over existing concrete or asphalt, cracked or spalled, Pave Prep strips stabilize and safeguard the new asphalt surface. *Details at right.*

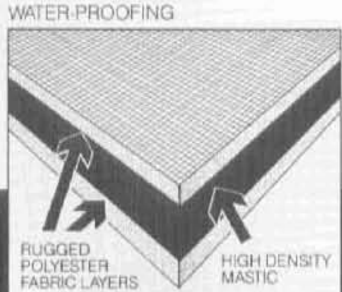
PARKING LOTS

HIGHWAYS & BRIDGES

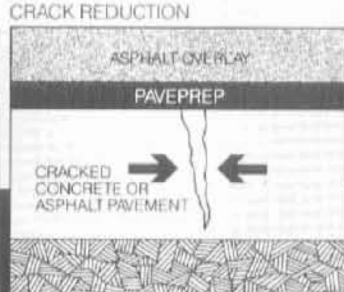
AIRPORT RUNWAYS & APRONS

CITY STREETS

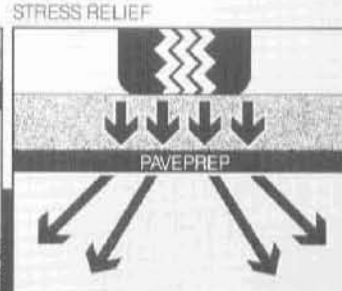
WATER-PROOFING



CRACK REDUCTION



STRESS RELIEF



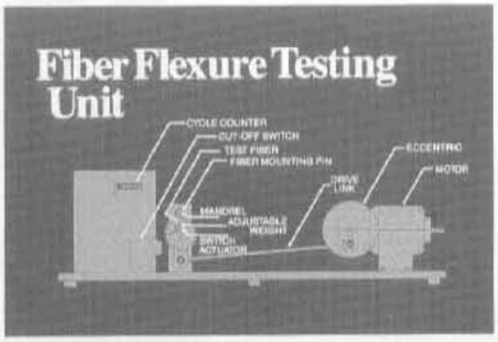
PavePrep Specifics

HEAT STABILITY	No dripping or delamination after 2 hours @ 190° (2" × 5" sample suspended vertically in mechanical convection oven)
FLAMMABILITY	Self-extinguishing/NBR (Federal FMVSS 302)
COLD FLEX	No separation (2" × 5" specimen, 180° bend on 2" mandrel @ 0°F)
POLYESTER REINFORCEMENT	Cycles to break* (single fiber), 2,100,000
EQUIVALENT GLASS REINFORCEMENT	Cycles to break (single fiber), 30,500
ELONGATION	100% (Instron)
TENSILE STRENGTH	1000 lbs. per inch width min. (Instron)
WEIGHT	0.9 lbs/ft²
DENSITY	80 lbs/ft³ (ASTM E 12-70)
CALIPER	0.135 in. † (ASTM D1777)
ABSORPTION	1% Max (ASTM D517-68)
BRITTLENESS	passes (ASTM D517-68)
SOFTENING POINT	200°F (min.) (ASTM D2398-68)

† 95% retained after loading
* Special flexing, non-abrading test method (details on request)

Widths: 12" - 20" - 36" - 42" (non-standard widths available on request)
Roll Lengths: 48' - 102'

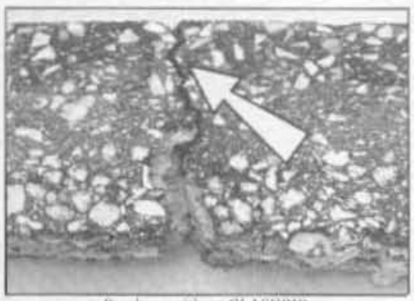
THE PAVEPREP SYSTEM IS PROTECTED BY U.S. PATENT NO. 4,417,939



Further detailed technical information, sample and prices are available from:

West Sales Office	4606 Wynn Road Las Vegas, Nevada 89103 702-362-4269 1-800-367-3939
Midwest Sales Office	105 May Drive Harrison, Ohio 45030 513-367-6540 1-800-544-7737 Fax: (1)-513-367-6543
East Sales Office	141 Central Avenue Westfield, NJ 07090 201-233-4444 1-800-233-7737 Fax: (1)-201-233-4215

INNOVATIVE NEW PAVEMENT REINFORCEMENT STRONGER THAN STEEL SHARPLY REDUCES PAVING AND MAINTENANCE COSTS



Roadway without **GLASGRID**
Crack breaking through to surface

Roadway with **GLASGRID**
Crack prevented from breaking through to surface

Reflection cracking virtually eliminated –

GLASGRID mesh, an engineered product from Bay Mills, offers a proven solution to the major problem of pavement cracking due to load and thermal effects. Glasgrid effectively changes the fundamental mode of crack propagation. (See illustration). When placed between the old pavement and new asphalt concrete overlay, GLASGRID disperses crack development, thus reducing crack break-through to the surface.

Exceptional Strength –

The secret of GLASGRID lies in glass fiber, which is stronger than steel, fabricated into a unique grid structure and protected with a special coating developed by Bay Mills Ltd. Each strand of the high modulus glass fiber is encapsulated in the coating which provides intimate bonding with the underlying pavement and permits utilisation of the potential strength inherent in glass fiber. High tensile GLASGRID significantly increases the load capacity of asphaltic overlays.

Cuts costs now and tomorrow –

Properly applied GLASGRID effectively reduces the need for repair and maintenance and can significantly reduce the frequency of overlaying pavement. In many applications, GLASGRID will permit the use of thinner overlays with corresponding cost savings.

Want More Information? –

Let a Bay Mills representative show you how to reduce reflective cracking and save money. Call or write:

BAY MILLS LTD.

MIDLAND SALES OFFICE
277 Lakeshore Rd. E., Suite 400
Oakville, Ontario L6J 6J3
Telephone (416) 842-8608
Telex: 0698-2459

GLASGRID

*Registered trade mark, patent pending

GLASGRID* PAVEMENT REINFORCEMENT

APPLICATIONS

GLASGRID glass fiber mesh is designed to reinforce asphalt concrete overlays in pavement construction. When placed between an existing pavement surface and asphalt overlay, GLASGRID will reduce both thermal and stress cracks breaking through the overlay to the surface. GLASGRID will also improve the structural capacity of asphalt concrete overlays.

GLASGRID's performance can lead to significant economies in both construction materials and maintenance costs.

MECHANICAL CHARACTERISTICS

*Tensile Strength
- Across Width — 100 kN/m
- Across Length — 50 kN/m

Modulus of Elasticity – 69,000,000 kPa (10,000,000 psi)

*Independent laboratory tests (November [illegible]) based on component strand strength

PRODUCT SPECIFICATIONS

Roll Length	up to 200 m
Roll Width	up to 4.0 m
Weight	300 g/m²
Material	Glass fiber with modified asphalt coating
Colour	Black
Grid Size	25 mm x 12.5 mm

INSTALLATION PROCEDURE

GLASGRID mesh can be installed on flexible pavements (asphalt concrete) and rigid pavements (portland cement concrete) using conventional paving procedures. However, GLASGRID mesh should not be used on structurally unsound pavements.

FLEXIBLE PAVEMENTS

SURFACE PREPARATION Perform any medial work such as base repairs, crack sealing, pothole filling, levelling course application, etc. that normally would be done during asphalt concrete overlay construction. Clean the pavement to be reinforced thoroughly to remove any deleterious material.

TACK-COAT APPLICATION A **uniform** application of CRS-1 emulsified asphalt **must** be applied in advance of GLASGRID placement. Recommended emulsion application rates vary from:

Tight Rich Surfaces – 0.20 l/m²
Old Open Surfaces – 0.50 l/m²

GLASGRID INSTALLATION GLASGRID can be applied manually or with mechanical equipment immediately after the initial "set" of the tack coat. Pavers and trucks can begin normal operations when the emulsified tack coat has **completely** "set." GLASGRID mesh must be firmly bonded to the existing pavement.

RIGID PAVEMENTS

Installation is the same as for flexible pavements except that a levelling course of asphaltic concrete (minimum 25 mm) must be placed prior to the tack coat and GLASGRID. GLASGRID is effective when it becomes encapsulated in the matrix to be reinforced.

RECOMMENDED ASPHALT CONCRETE OVERLAY THICKNESS TO REDUCE REFLECTIVE CRACKING

CONVENTIONAL PROCEDURES		PROCEDURE USING GLASGRID**	
1. Flexible Pavement	**2. Rigid Pavement**	**1. Flexible Pavement**	**2. Rigid Pavement**
Tack coat Minimum overlay thickness 75 mm of asphaltic concrete	Tack coat. Minimum overlay thickness 75-150 mm of asphaltic concrete. Limited success is expected using this technique.	Tack coat GLASGRID. Minimum overlay thickness – 40 mm of asphaltic concrete	Tack coat. Levelling course – 25 mm. Tack coat GLASGRID. Minimum asphaltic concrete overlay thickness – 40 mm

STOPS CRACKS IN THEIR TRACKS!

* GLASGRID is the Registered Trademark of Bay Mills Limited. Patent pending.

** The information presented herein, while not guaranteed, is to the best of our knowledge true and accurate. Except when agreed to in writing for specific conditions of use, no warranty or guarantee expressed or implied is made regarding the performance of any product, since the manner of use and handling are beyond our control. The user of such information assumes all risk connected with the use thereof. Nothing contained herein is to be construed as permission or as a recommendation to infringe any patent.

TAPECOAT

M-860 Specifications

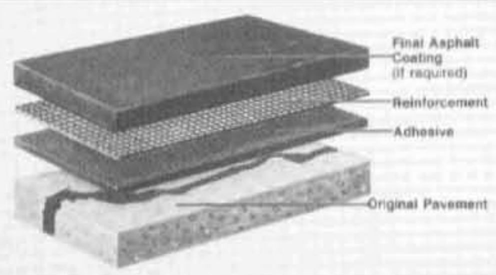
Tapecoat M-860 is a pre-formed, cold applied, self-adhering material that is impermeable to water and salt. The adhesive is manufactured from specially formulated elastomeric resins bonded to a woven polymer for high puncture resistance. The rolls have an easy-to-remove plastic release film that protects the adhesive from contamination prior to application.

Tapecoat M-860 should be applied over dry pavement that is free of dirt, debris or other foreign matter. When used as a temporary patching material, TC M-860 Primer should be placed on the surface and shall extend at least 1" wider than the material. The primer should be allowed to dry to the touch before applying Tapecoat M-860.

Packaged in cartons as follows: 3 rolls — 4" x 150'; 2 rolls — 6" x 150'; 1 roll — 12" x 150'. Additional widths up to 24" wide available upon request.

PHYSICAL PROPERTIES

PROPERTY	VALUE	TEST METHOD
Thickness	.065" Nominal	—
Water Vapor Transmission Rate, Permeance	0.01 perms (grains/sq.ft./hr./in. Hg) Maximum	ASTM E-96 Method B
Tensile Strength	50 lb./in. Minimum	ASTM D-882 Modified for 1" Opening
Puncture Resistance (Mesh)	200 lb. Minimum	ASTM E-154
Pliability-1/4" Mandrel 180° bend -30°F	No cracks in mesh or adhesive	ASTM D-146



The TAPECOAT Company
A DIVISION OF TC MANUFACTURING CO., INC.

P.O. Box 631, Evanston, IL 60204-0631
Phone: 312/866-8500 • Telex: 265541 TCMF UR

Printed in USA

TAPECOAT

M-860

...A Unique Repair Coating That Insures Added Life For Concrete And Asphalt Surfaces

The Tapecoat Company, a leader in the protective coating field since 1941, has broadened its line of quality products with the addition of a pressure sensitive pavement repair material. Tapecoat M-860 is a cold-applied, self-adhering, puncture-resistant product that has been designed to provide extended repair protection for concrete and asphalt surfaces.

Typical uses for Tapecoat M-860 are maintenance problems such as pot holes, cracks in paving material, pavement deformation at bus stops and other heavy-traffic areas and airport and bridge surface repair.

Used in conjunction with hot or cold patching materials, the unique, highly aggressive, pressure-sensitive adhesive provides excellent bonding to the substrate. It retains its ability to bond under pressure at temperatures as low as 0°F, an important consideration when fast, temporary repairs must be made during the winter months.

When combined with the additional mechanical strength received from the reinforcement material, Tapecoat M-860 provides the quick, easy and economical answer to your maintenance problems.

Supplied in easy-to-use rolls for fast, efficient application, Tapecoat M-860 is cost effective when used in combination with a complete asphalt overlay or alone as a temporary patching material.

ROADS AND STREETS

Tapecoat M-860 is easy to apply over cracks in pavements in long lengths as well as short cuts.

The plastic release film permits proper alignment over cracks and is easily removed for rapid application.

Once the Tapecoat M-860 is in place, pressure may be used to accelerate bonding to the surface being protected.

Due to its aggressive bonding capabilities, Tapecoat M-860 may also be used under a tack coat prior to new asphalt overlay.

For added service life, a full paving over the Tapecoat M-860 completes the job.

AIRPORTS

Airport surface deterioration is another practical target for the application of Tapecoat M-860.

BRIDGES

Tapecoat M-860 provides added protection against the destructive forces of water and salt on bridge decks.

FEATURES

- Excellent bond to concrete and asphalt surfaces
- High puncture-resistance
- Quick and easy application
- Pre-fabricated to provide uniform thickness
- Impermeable to water and salts
- Specially formulated adhesive to extend service life
- Cold-applied for safety during application
- Completely non-toxic
- Year-around use

APPENDIX B Bid Item Quantities and Unit Prices

ARIZONA DEPARTMENT OF TRANSPORTATION

DIVISION OF HIGHWAYS

DATE: 04/05/88

AGREEMENT ESTIMATE &
PROGRESS AND FINAL PAYMENT REPORT

CONTRACTOR: THE ASHTON CO INC

PROJECT NUMBER	TERMINI	LOCATION	FUND CODE	ITEM NUMBER
RS 274- (8)	WILLCOX-BONITA (SR 186)	REX ALLEN DRIVE	82512	0491

COUNTY	GROSS LENGTH	NET LENGTH	PREPARED BY	TYPE OF WORK
COCHISE	01.050	01.050	AG	MILL & RESURFACE

RECEIVED
MAY 16 1988
BENSON, ARIZONA

CS250-550-1 ARIZONA DEPARTMENT OF TRANSPORTATION PAGE 2

DIVISION OF HIGHWAYS DATE: 04/05/98

AGREEMENT ESTIMATE &

ESTIMATE NO: PROGRESS AND FINAL PAYMENT REPORT

PROJECT NO: FS 274- (8) SECTION: 01

CODE: FA 1000

BITUMINOUS CONCRETE ROADWAY

ITEM NO.	ITEM DESCRIPTION	UNIT	PLANS	REVISED	UNIT PRICE	ACCUM QTY	ACCUM AMT	PERCENTAGE
2020029	REMOVAL OF ASPHALTIC CONCRETE PAVEMENT	SQ.YD.	37,220 $31,637.00	37,220 $31,637.00	.85			
2060001	FURNISH WATER SUPPLY	L.SUM	1 $5,169.00	1 $5,169.00	5,169.00			
4040034	ASPHALT CEMENT (AC-30) (FOR 1/2" MIX)	TON	199 $29,850.00	199 $29,850.00	150.00			
40401[illegible]	BITUMINOUS TACK COAT	TON	6 $240.00	6 $240.00	40.00			
4040116	APPLY BITUMINOUS TACK COAT	HOUR	16 $2,000.00	16 $2,000.00	125.00			
4040131	PROVISIONAL SEAL COAT	TON	12 $2,400.00	12 $2,400.00	200.00			
4040136	APPLY PROVISIONAL SEAL COAT	HOUR	4 $340.00	4 $340.00	85.00			
4040163	BLOTTER MATERIAL	TON	37 $370.00	37 $370.00	10.00			
4060004	ASPHALTIC CONCRETE (1/2" MIX)	TON	3,868 $96,700.00	3,868 $96,700.00	25.00			
4060024	MINERAL ADMIXTURE (FOR 1/2" MIX)	TON	72 $5,760.00	72 $5,760.00	80.00			
4060951	PAVEMENT REINFORCEMENT FABRIC	SQ.YD.	15,450 $15,450.00	15,450 $15,450.00	1.00			
4060956	PAVEMENT REINFORCEMENT FABRIC	L.FT.	3,000 $2,100.00	3,000 $2,100.00	.70			
7010001	MAINTENANCE AND PROTECTION OF TRAFFIC	$LSUM	21,250 $21,250.00	21,250 $21,250.00	1.00			
7040003	PAVEMENT MARKING (WHITE HOT-SPRAYED THERMOPLASTIC)(0.0	L.FT.	3,000 $600.00	3,000 $600.00	.20			
7040004	PAVEMENT MARKING (YELLOW HOT-SPRAYED THERMOPLASTIC)(0.0	L.FT.	13,450 $2,690.00	13,450 $2,690.00	.20			

CS250-830-1

ARIZONA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
AGREEMENT ESTIMATE &
PROGRESS AND FINAL PAYMENT REPORT
SECTION: 01
CODE: EA I000

PAGE 3
DATE: 04/05/88

ESTIMATE NO:
PROJECT NO: RS 274-(9)

BITUMINOUS CONCRETE ROADWAY

ITEM NO.	ITEM DESCRIPTION	UNIT	PLANS	REVISED	UNIT PRICE	ACCUM QTY	ACCUM AMT	PERCENTAGE
7050022	PAVEMENT MARKING, PREFORMED, TYPE I, WHITE STRIPE	L.FT.	720 $900.00	720 $900.00	1.25			
7050023	PAVEMENT MARKING, PREFORMED, TYPE I, SINGLE ARROW	EACH	4 $448.00	4 $448.00	112.00			
7050026	PAVEMENT MARKING, PREFORMED, TYPE I LEGEND	EACH	2 $430.00	2 $430.00	215.00			
7060015	PAVEMENT MARKER, RAISED, TYPE D	EACH	800 $2,720.00	800 $2,720.00	3.40			
7060018	PAVEMENT MARKER, RAISED, TYPE G	EACH	270 $945.00	270 $945.00	3.50			
7320070	ELECTRICAL CONDUIT (3") (PVC)	L.FT.	270 $2,295.00	270 $2,295.00	8.50			
7320420	PULL BOX (NO. 7)	EACH	4 $1,300.00	4 $1,300.00	325.00			
9010001	MOBILIZATION	L.SUM	1 $8,421.00	1 $8,421.00	8,421.00			
9080289	CONCRETE WHEEL CHAIR RAMP (DETAIL A)	EACH	32 $20,800.00	32 $20,800.00	650.00			
		TOTALS:	$254,815.00	$254,815.00			$.00	

CS250-RRC-1

ARIZONA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
AGREEMENT ESTIMATE &
PROGRESS AND FINAL PAYMENT REPORT
SECTION: 32
CODE: FA Y080

DATE: 04/05/88

ESTIMATE NO:
PROJECT NO: RS 274- (5) P

TRAINING (CONSTRUCTION PROJ)

ITEM NO.	ITEM DESCRIPTION	UNIT	PLANS	REVISED	UNIT PRICE	ACCUM QTY	ACCUM AMT	PERCENTAGE
9230001	PROVIDE TRAINEES WITH ON-THE-JOB TRAINING	HOUR	200 $160.00	200 $160.00	.80			
		TOTALS:	$160.00	$160.00			$.00	

APPENDIX C ADOT Special Provisions for Fabric Installation

SECTION 406 - ASPHALTIC CONCRETE:

406-2 Asphaltic Concrete Mix Design Criteria: TABLE 406-1 of the Standard Specifications is modified to add:

The Minimum Index of Retained Strength shall be 50 percent for 1/2 inch mix.

Absorbed asphalt shall be 0-1.0 percent for 1/2 inch mix when tested in accordance with Arizona Test Method 815.

406-2 Asphaltic Concrete Mix Design Criteria: mix design criteria for effective voids in Table 406-1 of the Standard Specifications is revised to read:

Criteria	Requirements 1/2" Mix	Arizona Test Method
Effective Voids, Percent, Range	6.0 ± 0.2	815

406-3.02 Mineral Aggregate: Table 406-3 of the Standard Specifications is modified to add:

The Combined Bulk Specific Gravity shall be 2.35 to 2.85.

The Combined Water Absorption shall be 0 to 2.50.

406-3.02 Mineral Aggregate: Note 2 of Table 406-3 of the Standard Specifications is revised to read:

Abrasion shall be performed separately on samples from each source of mineral aggregate. All sources shall meet the requirements for abrasion

406-3.02 Mineral Aggregate: of the Standard Specifications is modified to add:

For comparative purposes, quantities shown in the bidding schedule have been calculated based on the following data:

	1/2" Mix
Unit Weight, Pounds per Cubic Foot	147
Percent, Asphalt Cement	5.0
Percent, Mineral Admixture	2.0

406-3.04 Bituminous Material: of the Standard Specifications is modified to add:

The grade of bituminous material to be used shall be AC-30.

406-6 Verification Testing: Table 406-6 of the Standard Specifications is modified to add:

The limiting value for the Index of Retained Strength shall be 45.

* Note: The limiting value for Index of Retained Strength should be 5 less than Index of Retained Strength.

406-6 Verification Testing: effective voids in Table 406-6 of the Standard Specifications is revised to read:

The allowable deviation from proposal targets for effective voids shall be ±1.0 percent. The requirement for limiting value for effective voids is hereby deleted.

ITEM 4060951 - PAVEMENT REINFORCING FABRIC

Description:

The work under this item consists of furnishing all equipment, materials, labor, and placing by use of mechanical equipment, between Sta. 56+31.32 to 79+78.5, a reinforcing interlayer between the milled surface and the surfacing course in accordance with the details shown on the project plans, these special provisions, and as directed by the Engineer.

Pavement reinforcing fabric shall be nonwoven polyester, polypropylene, or polypropylene/nylon materials conforming to the following when tested in conformance with the listed ASTM Designation:

Weight, Oz,/sq. yd., ASTM Designation: D 1910	3.0 to 8.0
Grab Tensile Strength (1-inch grip), Pounds, ASTM Designation: D 1117	90 min.
Elongation at Break, Percent, ASTM Designation: d 1117	40 min.
Fabric Thickness, ASTM Designation: D 461	30 to 100 mils

Pavement reinforcing fabric shall be accompanied with a Certificate of Compliance conforming to the provisions in Section 106.05 of the Standard Specifications.

The fabric shall be protected from exposure to ultraviolet rays and shall be kept dry until placed.

Construction Requirements:

Surface preparation shall involve cleaning the milled surface free of milling dust, dirt and moisture by methods approved by the Engineer.

Prior to the placement of the reinforcing fabric, the milled and cleaned surface shall receive a binder coat consisting of approximately 0.25 - 0.30 of a gallon per square yard of paving grade asphalt (AC-30). The exact rate of application will be determined by the Engineer.

The reinforcing fabric (interlayer) shall be unrolled and spread uniformly directly by the mechanical means on the coated surface. Transverse joints shall be overlapped a minimum of 12 inches, and the longitudinal joints shall be overlapped a minimum of 3 inches, and the lap joints shall be sealed with an application of binder coat. The rate of application shall be as specified above.

Fabric placement on the milled surface and subsequent application of the overlay shall be accomplished by the end of each shift. Milling operation shall not commence until notification of an approved AC mix design is received and in no case shall the milled surface be open to normal traffic longer than 72 hours before application of the fabric and subsequent overlay are initiated.

Fabric Laydown Equipment:

Mechanical laydown equipment shall be capable of handling full rolls of fabric, and shall be capable of laying the fabric smoothly, without excessive wrinkles and/or folds that lap. The test for lapping shall be made by gathering together the fabric in a wrinkle. If the height of the doubled portion of extra fabric is 1/2 inch or more, the fabric shall be cut to remove the wrinkle, then lapped in the direction of paving. When manual laydown is required, a length of standard one-inch pipe, together with suitable roll tension devices, shall be used. The fabric shall be unrolled, stretched, aligned and placed in increments of approximately 30 feet.

Application of Binder Coat:

The binder coat must be uniform spray applied at the specified rate. Quantity specified will vary with the condition of the milled surface, but will normally be applied at the rate of 0.25 to 0.30 gallons per square yard of residual asphalt.

At major intersections or other areas where vehicular speed changes and turning movements occur, it is recommended that the binder coat application be reduced by approximately 20% (0.20 to 0.25 gallons per square yard) to minimize the chance of a slippage plane developing. The exact location of these areas will be as specified by the Engineer. Care shall be taken to avoid tracking binder material onto the pavement reinforcing fabric or distorting the fabric. If necessary, exposed binder material shall be covered lightly with sand.

Traffic:

Only necessary construction equipment shall be allowed on the fabric until the application of the asphalt concrete overlay and subsequently opening to normal traffic. Public traffic shall not be allowed on the bare reinforcing fabric, except that public cross traffic shall be allowed to cross the fabric, under traffic control, after the contractor has placed a small quantity of asphalt concrete over the fabric. Construction equipment turning movements as well as sudden stops/starts on the fabric should be minimized.

Method of Measurement:

Measurement will be made by the square yard of fabric placed.

Basis of Pavement:

The accepted quantities of fabric placed, measured as provided above, will be paid for at the contract unit price per square yard, which price shall be full compensation for the work, complete in place, as specified and described herein and as shown on the plans. No measurement or additional compensation will be made for cleaning the milled asphaltic concrete surface or furnishing and applying the binder coat, the cost being considered as included in the cost of ITEM 4060951.

ITEM 4060956 - PAVEMENT REINFORCING FABRIC (INSTALLATION):

Description:

The work under this item consists of furnishing and applying three experimental pavement reinforcing fabrics which will function as interlayers between the milled surface and two inch AC inlay to control reflection cracking. These fabrics will be supplied by their respective manufacturers for experimental use and the work shall consist of furnishing the equipment, materials and labor required in applying these fabrics between Sta 24+30 and 56+53.32, to the milled surface directly over the existing transverse cracks in accordance with the details shown on the project plans, these special provisions, and as directed by the Engineer.

Surface preparation shall involve cleaning the milled surface free of milling dust, dirt and moisture by methods and equipment approved by the Engineer prior to the application of all pavement reinforcing fabrics.

Approximately 1,000 linear feet of 'Paveprep' will be supplied by the manufacturer. The material is a high density asphalt mastic sandwiched between two layers of polyester fabric. The material will be delivered to the jobsite in rolls that hold 102 feet of the 20 inch wide fabric. A tack coat of AC-30 paving grade asphalt shall be applied at the approximate rate of 0.10 gallons per square yard prior to applying the fabric. A distributor or motorized tar kettle, both equipped with a hand held wand are acceptable for the tack coat application. The width of the tacking should be the material width (20 inches) plus 3 to 4 inches and shall be applied no further in advance of the fabric placement than can be accomplished without loss of the tack coat adhesion. The tacking coverage should span the meandering cracks as evenly as possible so as to insure adhesion of the fabric edges.

No special equipment is needed for handling the fabric rolls. A steel bar or pipe can be inserted through the core for easy take-off or simply rolled along the crack manually. It should be unrolled so that the corners naturally turn down since it makes no difference which side of the fabric contacts the tacked surface. Where transverse and longitudinal cracks meet, or when splices are required, the fabric may be butted as neatly as possible by cutting with razor knives. Cornering can be accomplished without sectioning, if desired, by walking fabric to a point where gathering occurs, slicing out the bubble and tacking the overlap.

Approximately 1,000 linear feet of 'Tape Coat' M-860 will be supplied by the manufacturer and delivered to the jobsite in rolls 12 inches wide that contain 150 feet of the fabric. This material shall be applied to the cleaned surface in a manner similar to that recommended by 'Paveprep' except that <u>no tack coat</u> is required since the fabric is a cold applied and self adhering pressure sensitive material. The rolls have an easily removable plastic release film that protects the elastomeric resins from contamination prior to application. The manufacturer recommends applying rolling pressure after placement to accelerate bonding.

Approximately 1,000 linear feet of 'Glas Grid' will be supplied by the manufacturer and delivered to the jobsite in 5 foot wide rolls. This fabric does not require a tack coat since it is a self adhering material, although the manufacturer recommends utilizing a tractor mounted placement apparatus to achieve best results. The fabric shall be smooth and free of wrinkles and overlaps and shall be butt spliced, where required. Bonding shall be accomplished through the use of a rubber-tired roller.

Approximately 1,000 linear feet of pavement cracks will be designated for control purposes and will not receive a fabric application. The placement locations for each experimental fabric and those used for control purposes shall be as designated and recorded by the Engineer.

Method of Measurement:

Measurement will be made by the linear foot of fabric placed.

Basis of Payment:

The accepted quantities of fabric placed, measured as provided above, will be paid for at the contract unit price per linear foot, which price shall be full compensation for the work, complete in place, as specified and described herein and as shown on the plans. No measurement or additional compensation will be made for cleaning the milled asphaltic concrete surface or furnishing and applying the tack coat, when required, the cost being considered as included in the cost of ITEM 4060956.

APPENDIX D Project Construction Attendance

APPENDIX D

Project Construction Observers

The following persons were present during construction of the project:

Timothy Wolfe, Arizona Transportation Research Center
Guy Clerc, Project Supervisor, Safford Construction
Jon Woostencroft, Bay Mills Ltd.
Walter Zavitz, Tapecoat Company
Bruce Christianson, Paveprep Corporation
Gary Bowen, Contractor
Bob Sinohui, Inspector

APPENDIX E Asphalt Concrete Mix Design Verification

MATERIALS SECTION
ASPHALTIC CONCRETE MIX DESIGN VERIFICATION

H 0179 01C

PROJECT NUMBER: I-10-6-923   CONTRACTOR: ASHTON COMPANY   MIX TYPE: ADOT 1/2"
ORIGINATING LAB: W.T.I.TUCSON   DESIGN LAB NO: 88-313A   START DATE: 06/27/88

AGG. #	1	2	3	4	5	6
TYPE	BIN #3	BIN #2	BIN #1			
SOURCE	C 1255	C 1255	C 1255			
% USE	25.0	27.0	48.0			

	TYPE	SOURCE	PERCENT	SP. GR.
ASPHALT CEMENT:	AC-30	CHEVRON-RICHMOND	5.4	1.022
ADMIXTURE:	TYPE II	RILLITO	2.00	3.14

GRADATION (% PASSING)

SIEVE SIZE	GRAD. W/O ADMIXTURE	GRAD. W/ ADMIXTURE	VERIFICATION BAND W/O ADMIX.	CONTRACTORS TARGET W/ AD.	GRADATION BAND W/ AD.
1.5 IN.	100	100		100	100
1 IN.	100	100		100	100
3/4 IN.	100	100	100	100	100
1/2 IN.	98	98	94 - 100	97	90 - 100
3/8 IN.	78	78	73 - 79	76	70 - 85
1/4 IN.	59	60		60	
#4	52	53		56	
#8	44	45	44 - 48	47	44 - 52
#10	42	43		44	
#16	34	35		36	
#30	24	25		25	
#40	18	20	14 - 18	18	13 - 23
#50	11	13		12	
#100	4	6		5	
#200	2.2	4.1	1.2 - 2.2	3.6	3.0 - 7.5

AGGREGATE PROPERTIES: % ABRASION AT 100 REV. 4 500 REV. 19
SAND EQUIVALENT 68   % CRUSHED FACES 60

SPECIFIC GRAVITIES: O.D. COARSE 2.560 O.D. FINE 2.585 O.D. COMBINED 2.573
COMBINED WATER ABSORPTION: 1.32%

MIX PROPERTIES TO BE VERIFIED	ADOT RESULT	VERIFICATION BAND	CONTRACTORS RESULT	SPECIFICATION REQUIREMENT
STABILITY	2875	1750 +	2410	2000 +
FLOW	9	7 - 17	8	8 - 16
VMA	15.4	15.7 - 18.7	17.2	15.5 - 18.5
AIR VOIDS	3.9	4.9 - 6.9	5.9	5.8 - 6.2
RETAINED STRENGTH	67	45 +	53	50 +
WET STRENGTH	287	140 +	323	150 +

OTHER MIX PROPERTIES:

ASPHALT ABSORPTION 0.34 % MAXIMUM DENSITY 149.8 #/FT^3 AT 5.4 % ASPH.
BULK DENSITY 143.9 #/FT^3 % VOIDS FILLED 74.7 EFF. ASPHALT 5.1
FILM THICKNESS 12 MICRONS

REMARKS ON DESIGN

THIS DESIGN ALSO FOR PROJECT RS-274(8)P.
DESIGN FAILED VERIFICATION CRITERIA WITH LOW AIR VOIDS AND VMA.

APPROVED BY

MIX DESIGN NOT ACCEPTABLE

PRIVATE LAB MIX DESIGN TABULATION

DESIGN LAB # 88-313   DATE 06/29/88 ORIGINATING LAB: W.T.I.TUCSON
MIX TYPE ADOT 1/2"   PROJECT NUMBER: I-10-6-923

GRADATION TARGETS-- % PASSING

SIEVE	W/O ADMIX	W/ ADMIX
1.5 IN.	100	100
1 IN.	100	100
3/4 IN.	100	100
1/2 IN.	97	97
3/8 IN.	76	76
1/4 IN.	59	60
#4	55	56
#8	46	47
#10	43	44
#16	35	36
#30	23	25
#40	16	18
#50	10	12
#100	3	5
#200	1.7	3.6

DESIGN INFORMATION

ADMIXTURE: TYPE II   SOURCE: RILLITO   PERCENT: 2.00

ASPHALT: AC-30   SOURCE: CHEVRON-RICHMOND   SPECIFIC GRAVITY: 1.018

AGGREGATE: SAND EQUIVALENT 61 LOSS FROM ABRASION: 100 REV 4% 500 REV 21%
CRUSHED FACES 52
O.D. SP. GR.: COARSE 2.589 FINE 2.591 COMBINED 2.590
ABSORPTION: WATER 1.17% ASPHALT 0.37%

MIX: % ASPHALT 5.4 BULK DENSITY 141.7 #/FT^3   STABILITY 2410 FLOW 8
VMA 17.2% AIR VOIDS 5.9% RETAINED STRENGTH 53.0% WET STRENGTH 323 PSI

MAXIMUM THEORETICAL DENSITY IS 150.6 #/FT^3 AT 5.4 % ASPHALT

REMARKS: THIS DESIGN ALSO FOR PROJECT RS-274(8)P.

Douglas A. Forstie

JUL 19 1988

MATERIALS TESTING ENGINEER

TEST RESULTS FOR ADOT 1/2" MIX DESIGN, LAB # 88-313A . PROJECT NUMBER: I-10-6-923

AGGREGATE SAMᴾLES:

LAB #	TYPE	FROM	DATE	SOURCE	1"	3/4"	3/8"	#4	#8	#16	#40	#100	#200
88-313	BIN #3	BIN	06/22/88	C 1255	100.0	100.0	18.0	2.0	1.0	0.0	0.0	0.0	0.00
88-312	BIN #2	BIN	06/22/88	C 1255	100.0	100.0	93.0	16.0	2.0	0.4	0.4	0.4	0.40
88-311	BIN #1	BIN	06/22/88	C 1255	100.0	100.0	100.0	99.0	90.0	71.0	37.0	8.0	4.00
88-310	5/8"	STOCKPILE	06/22/88	C 1255	100.0	100.0	27.0	2.0	0.4	0.4	0.4	0.4	0.40
88-309	3/8"	STOCKPILE	06/22/88	C 1255	100.0	100.0	92.0	7.0	1.0	1.0	1.0	1.0	0.80
88-308	WFINES	STOCKPILE	06/22/88	C 1255	100.0	100.0	100.0	97.0	84.0	62.0	29.0	4.0	1.20

AGGREGATE SOURCES:
SOURCE NO: C 1255 DESCRIPTION: INDUSTRIAL ASPH.# 66

SPECIFIC GRAVITY TEST(S):

TEST #	TYPE	SOURCE NO.	OD SP. GR.	SSD SP. GR.	WATER ABSORPTION	USED IN DESIGN?
1	FINE	C 1255	2.585	2.614	1.09 %	YES
1	COARSE	C 1255	2.560	2.600	1.55 %	YES

MARSHALL TESTS:

TEST #	METHOD	DATE	% ASPHALT	%ADMIX	BULK DENSITY	STABILITY	FLOW	VMA	VOIDS	USED IN DESIGN?
1	MECH	06/30/88	5.4	2.0	143.9	2930	9	15.4	3.9	NO
2	HAND	06/30/88	5.4	2.0	145.2	3274	12	14.6	3.0	NO
3	MECH	07/01/88	5.4	2.0	143.9	2875	9	15.4	3.9	YES

RICE TESTS: (WITHOUT ADMIXTURE)

TEST #	DATE	% ASPHALT	MAXIMUM DENSITY	EFFECTIVE SP. GR.	USED IN DESIGN?
1	07/11/88	6.0	148.6	2.607	NO
2	07/12/88	6.0	148.0	2.595	YES

IMMERSION COMPRESSION TESTS:

TEST #	DATE	% ASPHALT	LOAD	MARSH. DENSITY	% OF MARSH. DENSITY	DRY STR.	WET STR.	RETAINED STR. %	USED IN DESIGN?
1	07/07/88	5.4	2150	143.9	95.1	428	287	67.1	YES

Douglas A. Forstie

JUL [illegible] 1988

MATERIALS TESTING ENGINEER

APPENDIX F Data and SPSS Analysis for Field Evaluation 1

F1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC
1		IDENTIFICATION				LOCATING INFORMATION												ASSUMED		OBSERVED				CRACK SEVERITY BY LANE					
2														DIST(i,i-1)		ROAD		ORIGINAL		CRACK		APPARENT							
3		SEQ. #		CRACK ID		STATION		WASHER		PAINT		OTHER				WIDTH (ft)		CRACK (ft)		LENGTH (ft)		% REFLECTED		WB-2	WB-1	MID	EB-1	EB-2	
4																						Y							
5		1		1A		24+30		0		EB		X-EB		N/A		43		43		8		17%		0	0	N/A	L	0	
6		2		1B		25+00		0		EB		X-EB,sign		70		50		50		0		0%		0	0	N/A	0	0	
7		3		1C		25+51		0		EB		X-EB		51		52		52		35		67%		L	L	N/A	0	0	
8		4		1D		28+20		0		EB		0		269		60		60		35		58%		L	L	L	L	L	
9		5		2A		29+02		EB,WB		EB		0		82		60		71		71	*	100%		L	L	L	L	L	
10		6		2B		30+00		EB		EB		0		98		60		71		71	*	100%		L	L	L	L	L	
11		7		2C		31+40		EB,WB		EB		0		140		60		61		61	*	100%		L	L	L	L	L	
12		8		2D		32+25		EB,WB		EB		0		65		60		60		60		100%		L	L	L	L	L	
13		9		3A		33+20		EB,WB		EB		0		35		60		69		69	*	100%		L	L	L	L	L	
14		10		3B		34+20		EB,WB		EB		0		100		60		60		28		47%		L	0	L	0	0	
15		11		3C		35+00		EB,WB		EB		0		80		60		60		2		3%		VL	0	0	0	0	
16		12		3D		36+70		EB,WB		WB		0		170		60		61		61	*	100%		L	L	L	L	L	
17		13		4A		37+75		EB,WB		WB		0		105		60		60		36		60%		L	L	L	L	0	
18		14		4B		38+98		EB,WB		WB		0		123		60		60		53		88%		L	L	M	L	L	
19		15		4C		39+55		EB,WB		WB		0		57		60		60		50		83%		L	L	L	L	L	
20		16		4D		41+05		EB,WB		WB		0		150		60		60		15		25%		L	L	0	0	0	
21		17		5A		41+70		EB,WB		WB		0		65		60		60		55		92%		L	L	L	L	L	
22		18		5B		43+30		EB,WB		WB		0		160		60		60		57		95%		L	L	L	L	L	
23		19		8B		44+45		EB,WB		WB		0		115		60		60		8		13%		0	VL	0	0	0	
24		20		8A		44+70		0		WB		0		25	*	60		60		32		53%		0	L	L	L	0	
25		21		5C		46+65		EB,WB		WB		0		195		60		60		52		87%		L	L	L	L	L	
26		22		8D		47+20		EB,WB		WB		0		55		60		62		62	*	100%		L	L	L	L	L	
27		23		5D	*	47+50		EB,WB		WB		0		30		60		60		58		97%		L	L	L	L	L	
28		24		6A	*	48+00		EB,WB		WB		0		50		60		60		42		70%		0	L	L	L	L	
29		25		6B		46+75		EB,WB		WB		0		75		60		60		54		90%		VL	VL	L	L	L	
30		26		6C		49+20		EB,WB		WB		0		45		60		60		32		53%		VL	0	L	VL	0	
31		27		6D		50+30		EB,WB		WB		0		110		60		60		56		97%		L	VL	L	VL	L	
32		28		8C		53+00		EB,WB		WB		0		270		60		60		26		43%		0	0	0	L	L	
33		29		7A		53+35		EB,WB		WB		0		35		60		60		58		97%		L	L	L	L	L	
34		30		7B		54+12		EB,WB		WB		0		77		60		60		20		33%		L	L	0	0	0	
35		31		7C		54+57		EB,WB		WB		0		45		60		60		42		70%		0	VL	L	VL	VL	
36		32		7D		55+12		EB,WB		WB		0		55		60		60		60		100%		L	L	L	L	L	
37																													
38		SUMMARY																											
39																		ASSUMED		OBSERVED		TOTAL		AVERAGE					
40				CODE		PRODUCT												ORIGINAL		CRACK		APPARENT		APPARENT					
41																		CRACK (ft)		LENGTH (ft)		% REFLECTED		% REFLECTED					
42																													
43				A		PAVEPREP												485		371		76%			70%				
44				B		GLASSGRID												481		291		60%			71%				
45				C		TAPECOAT												473		300		63%			73%				
46				D		CONTROL												493		403		85%			74%				

```
data list / product 1 reflect 2-4.
begin data.
      32 cases are written to the uncompressed active file.

This procedure was completed at 11:34:48
value labels product 1 'Pavepred' 2 'Glassgrid' 3 'Tapecoat' 4 'Control'.
means tables = reflect by product /statistic = 1.

***** Given WORKSPACE allows for  2966 Cells with  1 Dimensions for MEANS.
```

Summaries of REFLECT
By levels of PRODUCT

Variable	Value	Label	Mean	Std Dev	Cases
For Entire Population			69.9375	32.4325	32
PRODUCT	1	Pavepred	73.6250	29.5342	8
PRODUCT	2	Glassgrid	58.2500	39.9848	8
PRODUCT	3	Tapecoat	63.2500	30.4947	8
PRODUCT	4	Control	84.6250	28.0710	8

Total Cases = 32

Summaries of REFLECT
By levels of PRODUCT

Value	Label	Mean	Std Dev	Sum of Sq	Cases
1	Pavepred	73.6250	29.5342	6105.8750	8
2	Glassgrid	58.2500	39.9848	11191.5000	8
3	Tapecoat	63.2500	30.4947	6509.5000	8
4	Control	84.6250	28.0710	5515.8750	8
Within Groups Total		69.9375	32.3611	29322.7500	32

Criterion Variable REFLECT

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F	Sig.
Between Groups	3285.1250	3	1095.0417	1.0456	.3878
Within Groups	29322.7500	28	1047.2411		

Eta = .3174 Eta Squared = .1007

```
This procedure was completed at 11:34
t-test groups=product(1,4)/variables=r F2 ect.
```

Independent samples of PRODUCT

Group 1: PRODUCT EQ 1 Group 2: PRODUCT EQ 4

t-test for: REFLECT

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	8	73.6250	29.534	10.442
Group 2	8	84.6250	28.071	9.925

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.11	.897	-.76	14	.458	-.76	13.96	.458

This procedure was completed at 11:34:58
t-test groups=product(2,4)/variables=reflect.

Independent samples of PRODUCT

Group 1: PRODUCT EQ 2 Group 2: PRODUCT EQ 4

t-test for: REFLECT

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	8	58.2500	39.985	14.137
Group 2	8	84.6250	28.071	9.925

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
2.03	.371	-1.53	14	.149	-1.53	12.55	.152

This procedure was completed at 11:35:00
t-test groups=product(3,4)/variables=reflect.

Independent samples of PRODUCT

Group 1: PRODUCT EQ 3 F3 Group 2: PRODUCT EQ 4 t-tests for: REFLECT

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	8	63.2500	30.495	10.782
Group 2	8	84.6250	28.071	9.925

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
1.18	.833	-1.46	14	.167	-1.46	13.91	.167

This procedure was completed at 11:35:03

```
oneway variables=reflect by product (1,4) / ranges = duncan
                                          / contrast = 3*1 -3
                                          / statistics = 1.
```

- - - - - - - - - - - - O N E W A Y - - - - - - - - - - - -

Variable REFLECT
By Variable PRODUCT

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	3285.1250	1095.0417	1.0456	.3878
Within Groups	28	29322.7500	1047.2411		
Total	31	32607.8750			

Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	8	73.6250	29.5342	10.4419	48.9339	To	98.3161
Grp 2	8	58.2500	39.9848	14.1368	24.8219	To	91.6781
Grp 3	8	63.2500	30.4947	10.7815	37.7558	To	88.7442
Grp 4	8	84.6250	28.0710	9.9246	61.1571	To	108.0929
Total	32	69.9375	32.4325	5.7333	58.2443	To	81.6307

Group	Minimum	Maximum
Grp 1	17.0000	100.0000
Grp 2	.0000	100.0000
Grp 3	3.0000	100.0000
Grp 4	25.0000	100.0000
Total	.0000	100.0000

- - - - - - - - - - - O N E W A Y - - - - - - - - - - -

Variable REFL...
By Variable PRODUCT

Contrast Coefficient Matrix

	Grp 1	Grp 2	Grp 3	Grp 4
Contrast 1	1.0	1.0	1.0	-3.0

Pooled Variance Estimate

	Value	S. Error	T Value	D.F.	T Prob.
Contrast 1	-58.7500	39.6341	-1.482	28.0	.149

Separate Variance Estimate

	Value	S. Error	T Value	D.F.	T Prob.
Contrast 1	-58.7500	36.2161	-1.622	14.1	.127

- - - - - - - - - - - O N E W A Y - - - - - - - - - - -

Variable REFLECT
By Variable PRODUCT

Multiple Range Test

Duncan Procedure
Ranges for the .050 level -

2.89 3.04 3.14

The ranges above are table ranges.
The value actually compared with Mean(J)-Mean(I) is..
22.8828 * Range * Sqrt(1/N(I) + 1/N(J))

No two groups are significantly different at the .050 level

Homogeneous Subsets (Subsets of groups, whose highest and lowest means do not differ by more than the shortest significant range for a subset of that size)

SUBSET 1

no di...

Group	Grp 2	Grp 3	Grp 1	Grp 4
Mean	58.2500	63.2500	73.6250	84.6250

APPENDIX G Data and SPSS Analysis for Field Evaluation 2

IDENTIFICATION		LOCATION INFORMATION			DISTANCE FROM		ASSUMED	OBSERVED			
			WASHER		PREVIOUS	ROAD	ORIGINAL	CRACK	APPARENT	CRACK	ALLIGATOR
SEQ #	CRACK ID	STATION	North	South	(ft)	WIDTH (ft)	CRACK (ft)	LENGTH (ft)	REFLECTED	SEVERITY	CRACKING
1	1A	24+30	No	No	N/A	48	48	0	0%	N/A	N/A
2	1B	25+00	No	No	70	50	50	35	70%	L	N
3	1C	25+44	No	No	44	52	52	45	87%	M to H	N
4	1D	27+97	No	No	253	60	60	60	100%	M	N
5	2A	28+90	Yes	No	93	60	60	60	100%	M	Y
6	2B	29+86	No	No	96	60	60	60	100%	M	Y
7	2C	31+07	Yes	Yes	121	60	60	60	100%	M	Y
8	2D	31+85	No	Yes	78	60	60	57	95%	M	N
9	3A	32+89	No	Yes	104	60	60	60	100%	M	Y
10	3B	33+75	Yes	Yes	86	60	60	60	100%	M	Y
11	3C	34+48	Yes	Yes	73	60	60	48	80%	L	N
12	3D	35+51	Yes	Yes	103	60	60	60	100%	M	N
13	4A	36+57	Yes	Yes	106	60	60	60	100%	L to M	N
14	4B	37+81	Yes	Yes	124	60	60	59	98%	L	N
15	4C	38+35	No	No	54	60	60	60	100%	L to M	N
16	4D	39+50	Yes	Yes	115	60	60	60	100%	M	N
17	5A	40+50	Yes	Yes	100	60	60	60	100%	L to M	Y
18	5B	42+13	Yes	Yes	163	60	60	60	100%	M	N
19	8B	42+89	Yes	Yes	76	60	60	60	100%	M	N
20	8A	43+33	Yes	No	44	60	60	53	88%	L	N
21	5C	45+45	Yes	Yes	212	60	60	51	85%	L to M	Y
22	8D	46+27	Yes	Yes	82	60	60	60	100%	L to M	N
23	5D	46+57	Yes	Yes	30	60	60	60	100%	L to M	N
24	6A	47+07	Yes	Yes	50	60	60	60	100%	L to M	N
25	6B	47+69	No	Yes	62	60	60	60	100%	L	N
26	6C	48+11	Yes	Yes	42	60	60	60	100%	L	N
27	6D	49+11	Yes	Yes	100	60	60	60	100%	L to M	N
28	8C	51+66	Yes	Yes	255	60	60	60	100%	L	N
29	7A	52+09	Yes	Yes	43	60	60	60	100%	L to M	Y
30	7B	52+75	Yes	Yes	66	60	60	60	100%	L	N
31	7C	53+25	Yes	Yes	50	60	60	60	100%	L	Y
32	7D	53+83	Yes	Yes	58	60	60	60	100%	L to M	N

SUMMARY

CODE	PRODUCT		ASSUMED ORIGINAL CRACK (ft)	OBSERVED CRACK LENGTH (ft)	TOTAL APPARENT REFLECTED	AVERAGE APPARENT REFLECTED
A	PAVEPREP	(Sta. 24+30 ignored-see FE#2 report)	420	413	98%	98%
B	GLASSGRID		470	454	97%	97%
C	TAPECOAT		472	444	94%	98%
D	CONTROL		480	477	99%	98%

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```
INC 'EXAMPLE1.PGM'
DATA LIST /FABRIC 1 CRACK 3-8(2).

VARIABLE LABLES FABRIC 'PAVING FABRIC'
/CRACK 'PERCENTAGE OF CRACK LENGTH REFLECTED'.

VALUE LABLES FABRIC 1 'A-PAVEPREP' 2 'B-GLASSGRID' 3 'C-TAPECOAT' 4 'D-CONTROL'.

BEGIN DATA.
END DATA.
     31 cases are written to the compressed active file.

This procedure was completed at 10:55:24

LIST VARIABLES=FABRIC TO CRACK /CASES=31.
```

FABRIC	CRACK
1	100.00
1	100.00
1	100.00
1	100.00
1	88.00
1	100.00
1	100.00
2	70.00
2	100.00
2	100.00
2	98.00
2	100.00
2	100.00
2	100.00
2	100.00
3	87.00
3	100.00
3	80.00
3	100.00
3	85.00
3	100.00
3	100.00
3	100.00
4	100.00
4	95.00
4	100.00
4	100.00
4	100.00
4	100.00
4	100.00
4	100.00

Number of cases read = 31 Number of cases listed = 31

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This procedure was completed at 10:55:32

```
ONEWAY CRACK BY FABRIC(1,4)
/RANGES=DUNCAN(0.05)
/STATISTICS=ALL.
```

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Variable CRACK PERCENTAGE OF CRACK LENGTH REFLECTED
By Variable FABRIC PAVING FABRIC

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
Between Groups	3	136.1803	45.3934	.8587	.4744
Within Groups	27	1427.3036	52.8631		
Total	30	1563.4839			

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Group	Count	Mean	Standard Deviation	Standard Error	95 Pct Conf Int for Mean		
Grp 1	7	98.2857	4.5356	1.7143	94.0910	To	102.4804
Grp 2	8	96.0000	10.5289	3.7225	87.1977	To	104.8023
Grp 3	8	94.0000	8.5021	3.0059	86.8921	To	101.1079
Grp 4	8	99.3750	1.7678	.6250	97.8971	To	100.8529
Total	31	96.8710	7.2192	1.2966	94.2230	To	99.5190
	Fixed Effects Model		7.2707	1.3059	94.1916	To	99.5504
	Random Effects Model			1.3059	92.7152	To	101.0267

WARNING - Between component variance is negative
it was replaced by 0.0 in computing above random effects measures

Random Effects Model - Estimate of Between Component Variance -.9648

- - - - - - - - - - O N E W A Y - - - - - - - - - -

Group	Minimum	Maximum
Grp 1	88.0000	100.0000
Grp 2	70.0000	100.0000
Grp 3	80.0000	100.0000
Grp 4	95.0000	100.0000
Total	70.0000	100.0000

Tests for Homogeneity of Variances

Cochrans C = Max. Variance/Sum(Variances) = .5360, P = .050 (Approx.)
Bartlett-Box F = 5.739 , P = .001
Maximum Variance / Minimum Variance 35.474

- - - - - - - - - - O N E W A Y - - - - - - - - - -

Variable CRACK PERCENTAGE OF CRACK LENGTH REFLECTED
By Variable FABRIC PAVING FABRIC

Multiple Range Test

Duncan Procedure
Ranges for the .050 level -

2.90 3.05 3.15

The ranges above are table ranges.
The value actually compared with Mean(J)-Mean(I) is..
5.1412 * Range * Sqrt(1/N(I) + 1/N(J))

No two groups are significantly different at the .050 level

This procedure was completed at 11:15:07
T-TEST GROUPS=FABRIC(1,4)/VARIABLE=CRACK.

Independent samples of FABRIC PAVING FABRIC

Group 1: FABRIC EQ 1 Group 2: FABRIC EQ 4

t-test for: CRACK PERCENTAGE OF CRACK LENGTH REFLECTED

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	7	98.2857	4.536	1.714
Group 2	8	99.3750	1.768	.625

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
6.58	.026	-.63	13	.540	-.60	7.59	.568

This procedure was completed at 11:15:28
T-TEST GROUPS=FABRIC(2,4)/VARIABLE=CRACK.

Independent samples of FABRIC PAVING FABRIC

Group 1: FABRIC EQ 2 Group 2: FABRIC EQ 4

t-test for: CRACK PERCENTAGE OF CRACK LENGTH REFLECTED

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	8	96.0000	10.529	3.723
Group 2	8	99.3750	1.768	.625

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
35.47	.000	-.89	14	.386	-.89	7.39	.399

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This procedure was completed at 11:15:53
T-TEST GROUPS=FABRIC(3,4)/VARIABLE=CRACK.

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Independent samples of FABRIC PAVING FABRIC

Group 1: FABRIC EQ 3 Group 2: FABRIC EQ 4

t-test for: CRACK PERCENTAGE OF CRACK LENGTH REFLECTED

	Number of Cases	Mean	Standard Deviation	Standard Error
Group 1	8	94.0000	8.502	3.006
Group 2	8	99.3750	1.768	.625

		Pooled Variance Estimate			Separate Variance Estimate		
F Value	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.	t Value	Degrees of Freedom	2-Tail Prob.
23.13	.000	-1.75	14	.102	-1.75	7.60	.120

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This procedure was completed at 11:16:00
FINISH.

End of Include file.

APPENDIX H DESCRIPTION OF SINGLE-SAMPLING PLAN USED FOR CORE SAMPLES

A sampling plan requires testing each item in a random sample of **n** items from a lot of **N** items. If the number of defectives, **d**, is less than or equal to a predetermined value **c**, the entire lot is accepted. If **d** exceeds **c**, the lot is rejected.

The ability of a sampling plan to discriminate between acceptable and not acceptable lots is often developed using an Operating Characteristic (OC) Curve.

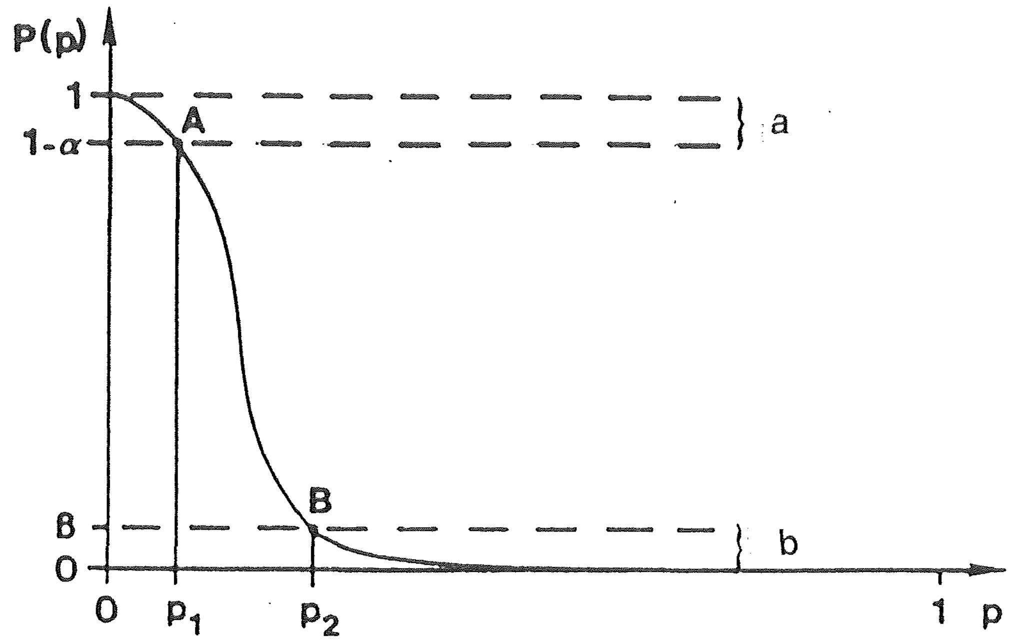


Figure 1 An OC-curve (From Stoodley et. al.)

Chapter 5 of Applied Statistical Techniques by Stoodley, Lewis, and Stainton further describe how given the points p_1 and p_2, and the producers risk (1-**a**) and consumers risk (**b**) can be used with the X^2 distribution to determine the above mentioned parameters **n** and **c**.

For the core sample sampling plan used with the paving fabric project, values p_1, p_2, and were determined based on the similarity of the cracks. As mentioned in the report, 4 of the 8 cracks of a particular treatment proving to be reflective and through the fabric was deemed enough to accept the lot of treated cracks. This ratio, 4/8, is p_1. p_2 is the ratio 6/8, that which would lead to immediately rejecting the lot of treated cracks. Corresponding risks, **a** and **b**, were chosen as .05 and .10, respectively.

Calculations using the X^2 distribution resulting in an **n** value of 78 and a **c** value of 49. The ratio of **c** to **n** is 0.6282. Because of the limited number of cracks per treatment, and the costs involved in core sampling, A decision was made to formulate a procedure minimizing the number of samples necessary. This was done by using the **c** to **n** ratio of 0.6282 rather than a **c** value of 49 and a **n** value of 78. The final plan resulted in a minimum of 8 cores and a maximum of 16, and is described in the body of the report.

APPENDIX I PHOTOGRAPHIC COMPARISON OF CRACKS

(a) Taken in 1989 (b) Taken in 1991

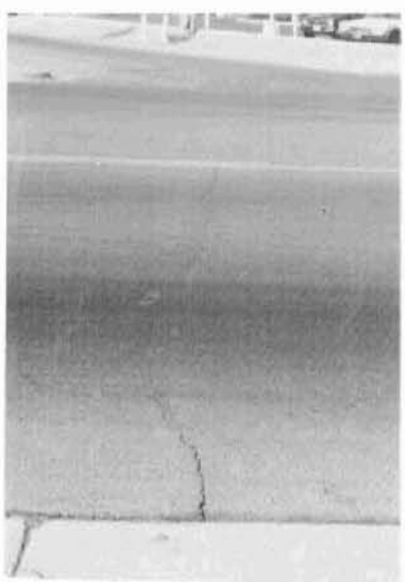
Crack 1C (a)

(b)

Crack 1D (a)

(b)

Crack 2B (a)



(b)

Crack 2D (a)

(b)

Crack 3B (a)

(b)

Crack 3C (a)

(b)

Crack 3D (a)

(b)

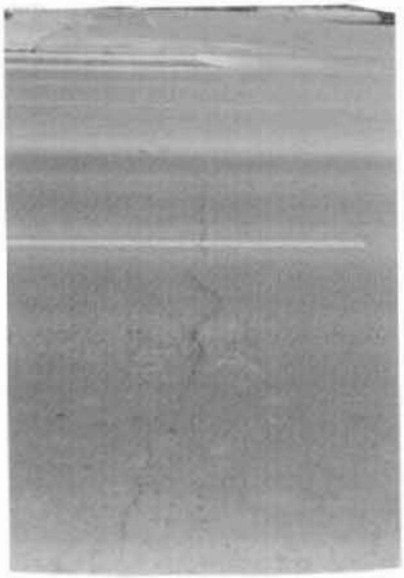
Crack 4A (a)

(b)

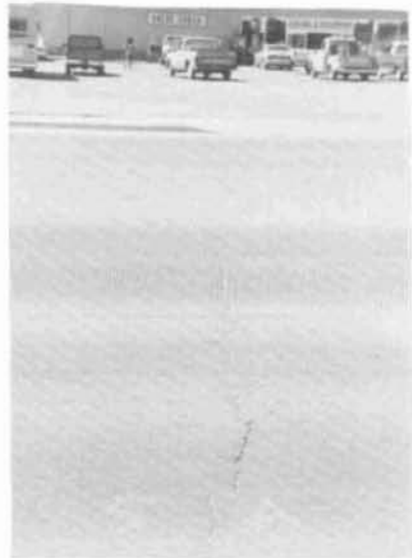
Crack 4B (a)

(b)

Crack 5A (a)



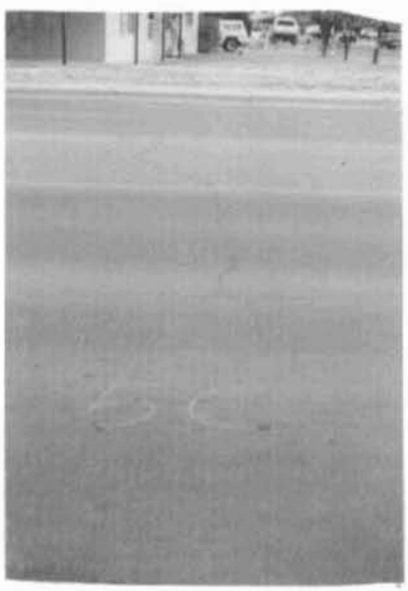
(b)



Crack 5B (a)

(b)

Crack 5C (a)



(b)

Crack 6B (a)

(b)

Crack 6D (a)

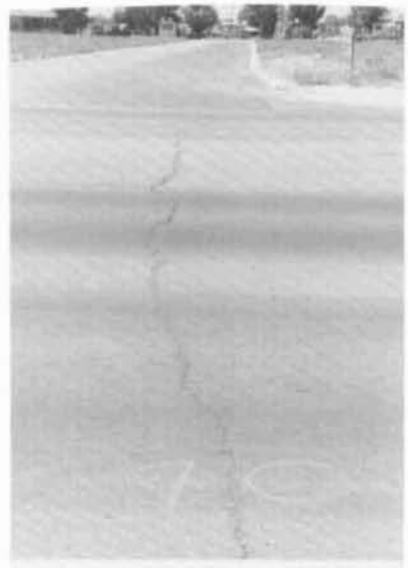
(b)

Crack 7A (a)

(b)

Crack 7C (a)

(b)



Crack 7D (a)

(b)

Crack 8C (a)

(b)

Crack 8D

(a)

(b)