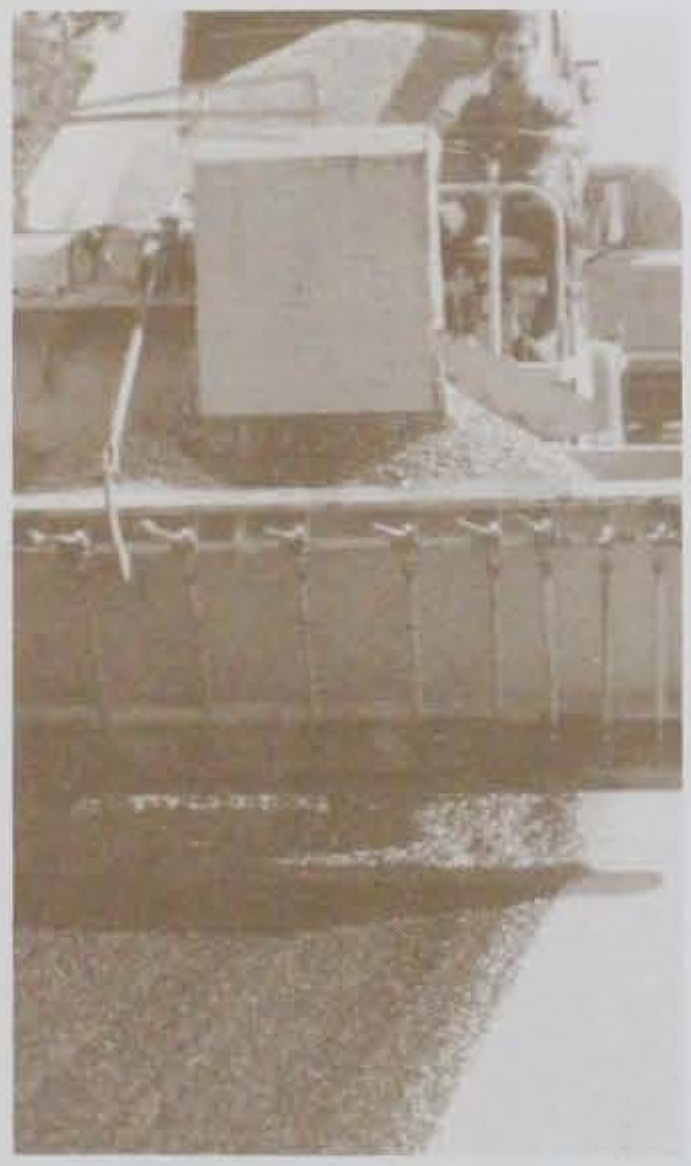
US Army Corps of Engineers



GEOTECHNICAL LABORATORY

MISCELLANEOUS PAPER GL-86-34

EVALUATION OF ASPHALT RUBBER AND ENGINEERING FABRICS AS PAVEMENT INTERLAYERS

by

R. C. Ahlrich

Geotechnical Laboratory

DEPARTMENT OF THE ARMY
Waterways Experiment Station, Corps of Engineers
PO Box 631, Vicksburg, Mississippi 39180-0631

November 1986

Final Report

Prepared for DEPARTMENT OF THE ARMY
US Army Corps of Engineers
Washington, DC 20314-1000

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY 2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited
4. PERFORMING ORGANIZATION REPORT NUMBER(S) Miscellaneous Paper GL-86-34	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION USAEWES Geotechnical Laboratory — 6b. OFFICE SYMBOL (If applicable) WESGP-IM	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) PO Box 631 Vicksburg, MS 39180-0631	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING / SPONSORING ORGANIZATION US Army Corps of Engineers — 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) Washington, DC 20314-1000	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. | PROJECT NO. | TASK NO. | WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)
Evaluation of Asphalt Rubber and Engineering Fabrics as Pavement Interlayers

12. PERSONAL AUTHOR(S)
Ahlrich, R. C.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final report	FROM Oct 83 TO Sep 84	November 1986	48

16. SUPPLEMENTARY NOTATION
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB-GROUP	Asphalt concrete overlay	Reflective cracking
			Asphalt - rubber interlayer	Stress relieving interlayer
			Engineering fabrics	

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

Asphalt-rubber and engineering fabric interlayers have been used to retard reflective cracks in asphalt concrete overlays. These materials have generally performed satisfactorily in warm climates; however, performance in cold climates has been less than desirable. The information presented in this study was obtained from experimental projects conducted by state and federal agencies.

The asphalt-rubber and engineering fabric rehabilitation techniques have been used to retard the reflection of cracks in existing asphalt concrete and portland cement concrete pavements through asphalt concrete overlays. These rehabilitation techniques also decrease the size of cracks that reflect through, thus retarding the amount of water penetrating into the base course and underlying subgrade.

(Continued)

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code) | 22c. OFFICE SYMBOL

19. ABSTRACT (Continued).

Guidance is provided for using asphalt rubber and engineering fabrics to maximize performance in reducing reflective cracking. This study should result in improved performance of overlays and, subsequently, substantial monetary savings to the taxpayers.

PREFACE

The study reported herein was conducted by the US Army Engineer Waterways Experiment Station (WES), Geotechnical Laboratory (GL), for the Office, Chief of Engineers, US Army, under the Facilities Investigation and Studies Program. This work was performed from October 1983 to September 1984 under the project entitled "Evaluation of Asphalt Rubber and Engineering Fabrics as Pavement Interlayers."

The study was conducted under the general supervision of Dr. W. F. Marcuson III, Chief, GL. The work was under the direct supervision of Dr. T. D. White, former Chief, Pavement Systems Division (PSD), Messrs. H. H. Ulery, Jr., Chief, PSD, and J. W. Hall, Jr., Chief, Engineering Investigations, Testing, and Validation Group. Personnel actively engaged in the planning, analyzing, and reporting phases of this study were Messrs. L. N. Godwin and R. C. Ahlrich, PSD, and Dr. E. R. Brown, PSD. This report was written by Mr. Ahlrich. Ms. Odell F. Allen, Information Products Division, Information Technology Laboratory, edited the report.

COL Allen F. Grum, USA, was the previous Director of WES. COL Dwayne G. Lee, CE, is the present Commander and Director. Dr. Robert W. Whalin is Technical Director.

CONTENTS

EVALUATION OF ASPHALT RUBBER AND ENGINEERING FABRICS AS PAVEMENT INTERLAYERS

PART I: INTRODUCTION

Background

1. As more and more of the nation's pavements approach the end of their design life, rehabilitation techniques that provide improved performance at lower costs are becoming more important. One of the shortcomings of most pavement repair techniques used for rehabilitation is the eventual occurrence of reflective cracking, the development of a crack pattern almost identical to that in the pavement which was overlaid. Reflective cracks are often found in asphalt concrete (AC) overlays of either portland cement concrete (PCC) or AC. Rehabilitation techniques used to prevent or delay reflective cracks have been under investigation for many years.

2. Reflective cracks are fractures in the overlay which result from movement of cracks and joints in the underlying pavement layers. These cracks are caused by vertical and horizontal movements of the pavement that has been resurfaced. Vertical movements are caused by traffic loads, and horizontal movements are caused by temperature and moisture changes. Without some form of prevention or reduction of these reflective cracks, early deterioration of an AC overlay occurs.

3. Methods for reducing reflective cracking in AC overlays have been tested in the field since the early 1930's and in the laboratory since the 1970's. One method that has been partially successful in retarding reflection cracks in overlays covering both PCC pavements and AC pavements is a stress-relieving interlayer. The stress-relieving interlayer consists of an asphalt-rubber mixture or engineering fabric. The asphalt-rubber interlayer is also referred to as a stress absorbing membrane interlayer (SAMI).

Objective

4. The objective of this study was to investigate the performance of asphalt rubber and engineering fabric as an interlayer to retard reflective

cracking and to make recommendations concerning their use.

Scope

5. This study was conducted to evaluate the effectiveness of interlayers to retard reflective cracking. An investigation was undertaken to obtain information relating to the performance of interlayers. A literature survey was conducted to review the efforts of state and federal agencies. Engineering personnel at state and federal levels were contacted to discuss the performance of interlayers at their installations. Specific sites at various locations throughout the country were selected for site visitation and inspection.

6. From the data obtained in the literature review, discussions with engineering personnel, and site inspections, performance of asphalt-rubber and engineering fabric interlayers was determined.

PART II: LITERATURE SURVEY

7. Since the early 1970's, stress-relieving interlayers, including asphalt rubber and engineering fabrics, have been widely used in experiments designed to retard or prevent reflective cracking. A majority of the experimental construction was initiated by the Federal Highway Administration (FHWA) in the National Experimental and Evaluation Program Project No. 10 (Sherman 1982). This project was set up to verify the effectiveness of the interlayers in field experiments involving AC overlays on both AC and PCC pavements. For AC pavements, the interlayers were designed to prevent or retard the reflection of transverse, longitudinal, and fatigue cracks. The purposes of the interlayers when overlaying PCC pavement were to slow the reflection of longitudinal and transverse joints in the AC overlay and to reduce the size of these reflected cracks.

8. In the literature survey concerning previous field experiments, engineering fabrics under an AC overlay have been tested extensively. These synthetic fabrics are manufactured from many different fibers and combinations of fibers, with polypropylene and polyester being the principal fabrics used in pavement rehabilitation. The fabric interlayers for overlays of AC and PCC pavements have the capability of reducing reflective cracking and waterproofing the base course from surface water.

9. AC overlays that are placed on PCC pavements are subject to vertical and horizontal movements. In order to obtain satisfactory results from the overlay, the slabs must be stabilized with grouting materials before the rehabilitation technique is applied. The differential movement of the pavement should be kept to a minimum of less than 0.002 in. (0.00508 cm) in order to achieve maximum usage of the interlayers (McGhee 1975).

10. The fabric interlayers are used in two different capacities on PCC pavements: the full-width and strip methods. The full-width method involves sealing the cracks and joints, placing a leveling course of AC in most cases, applying a tack coat, placing the engineering fabric, and finally overlaying with AC. The strip method involves the sealing of cracks and joints with no leveling course required. The single strips, usually 12 to 24 in. (30.48 to 60.96 cm) wide, are placed directly on the joints and cracks after the application of a primer. Then the entire pavement is overlaid with AC. These

methods have been a part of many experiments in many states with results ranging from very favorable to unfavorable.

11. The Georgia Department of Transportation (DOT) has done an extensive amount of work using these methods to rehabilitate PCC pavements in its interstate system. Several projects have been constructed comparing the full-width application of an engineering fabric and a single waterproofing strip, a woven or nonwoven fabric embedded in a thick layer of self-adhesive rubberized asphalt, to a control section. The Georgia DOT also used these projects to compare overlay thicknesses of 2, 4, and 6 in. (5.08, 10.16, and 15.24 cm). These projects showed the benefit of thicker overlays and that retardation of reflective cracking can be obtained with the use of fabrics. The percentage of cracks reflecting through an overlay as a function of time for a project located in Gwinnett County on Interstate 85 is shown in Figures 1 through 3 (Gulden and Brown 1983). The number of cracks reflecting through the 2- and 4-in. overlays is much greater in the control test section than that for the sections containing fabric interlayers. The figures show that in the control sections, 60 percent of the joints in the original pavement has reflected through the pavement in 1 to 3 years and that in the engineering fabric sections, 60 percent reflection takes two to six times as long.

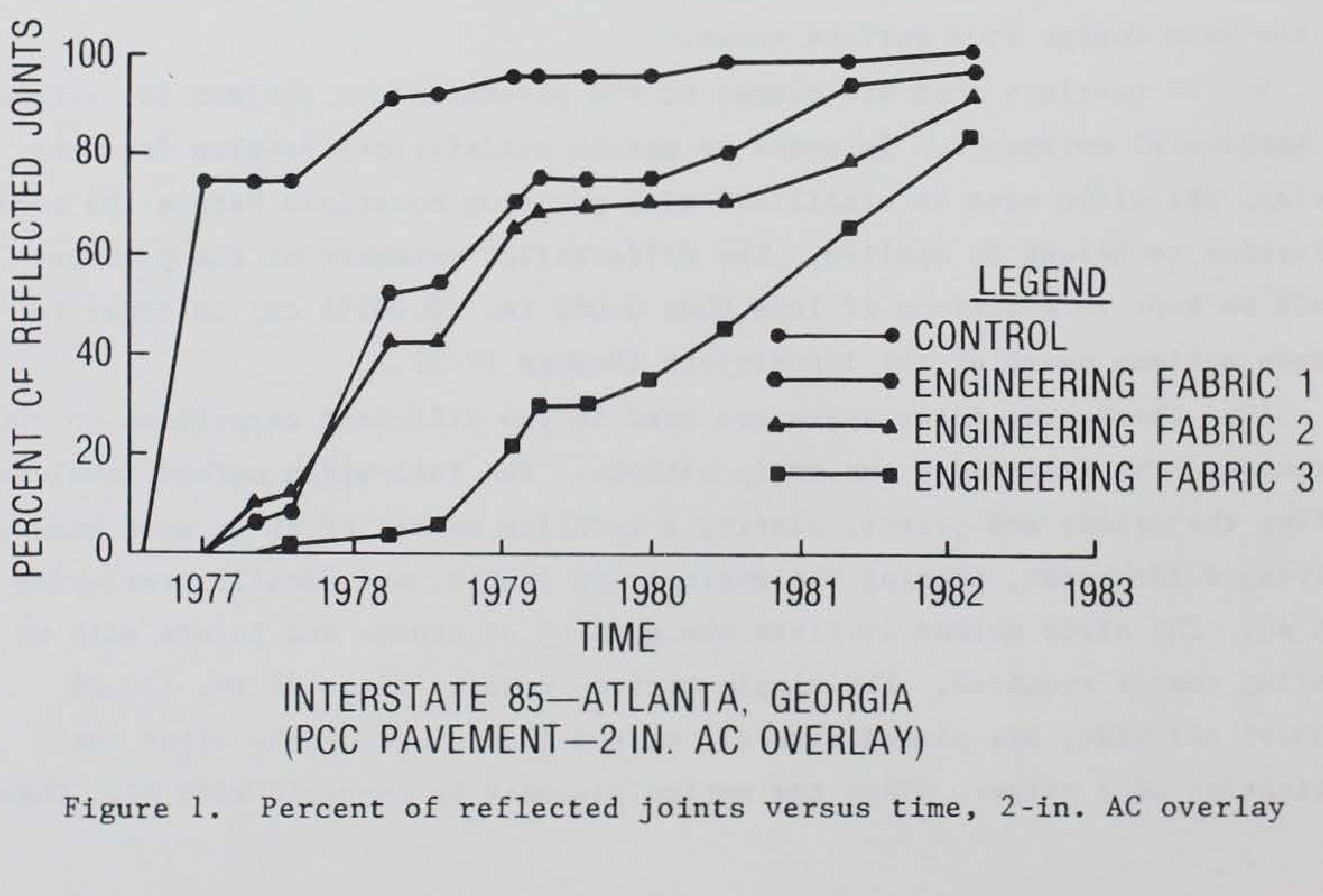


Figure 1. Percent of reflected joints versus time, 2-in. AC overlay

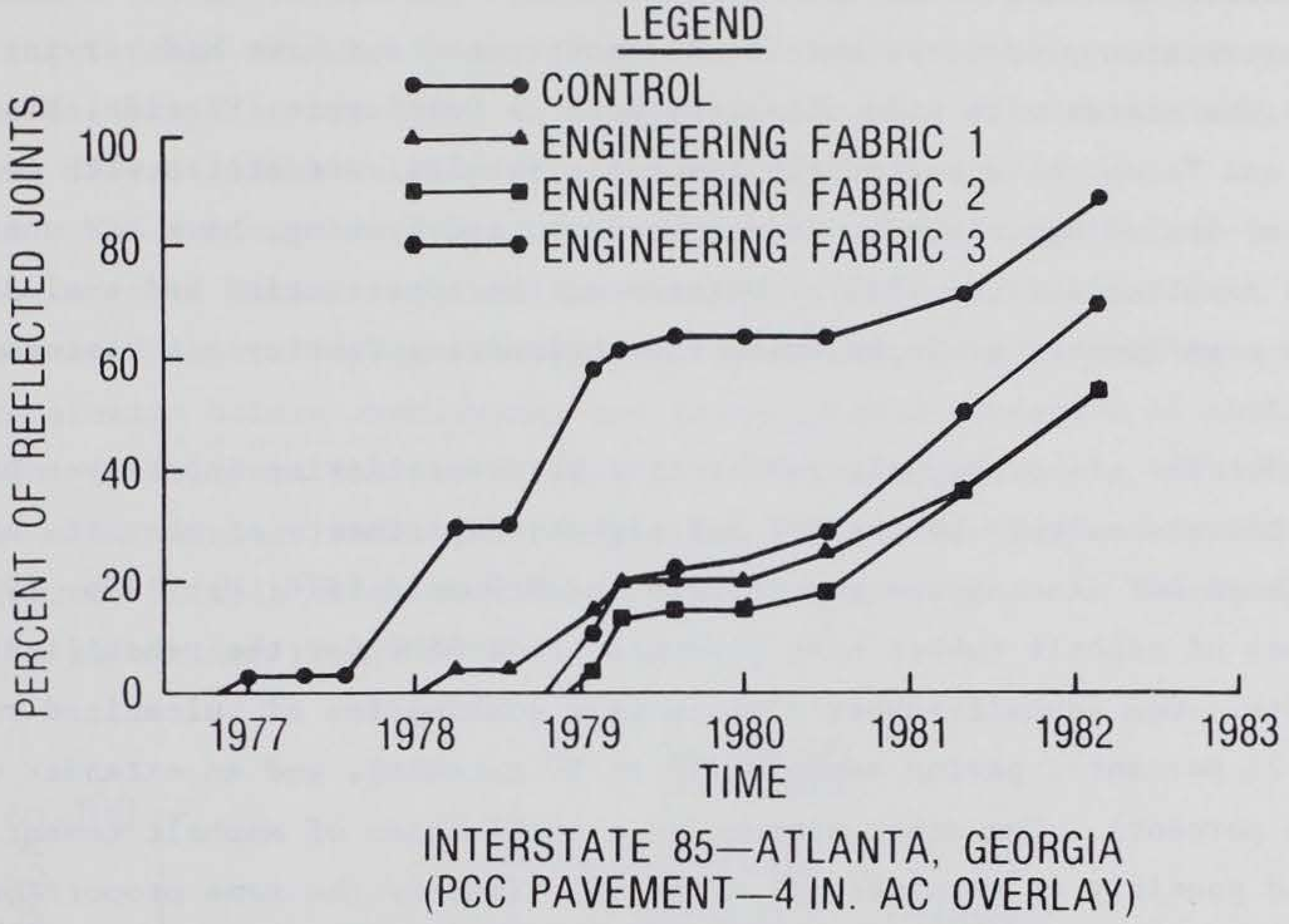


Figure 2. Percent of reflected joints versus time, 4-in. AC overlay

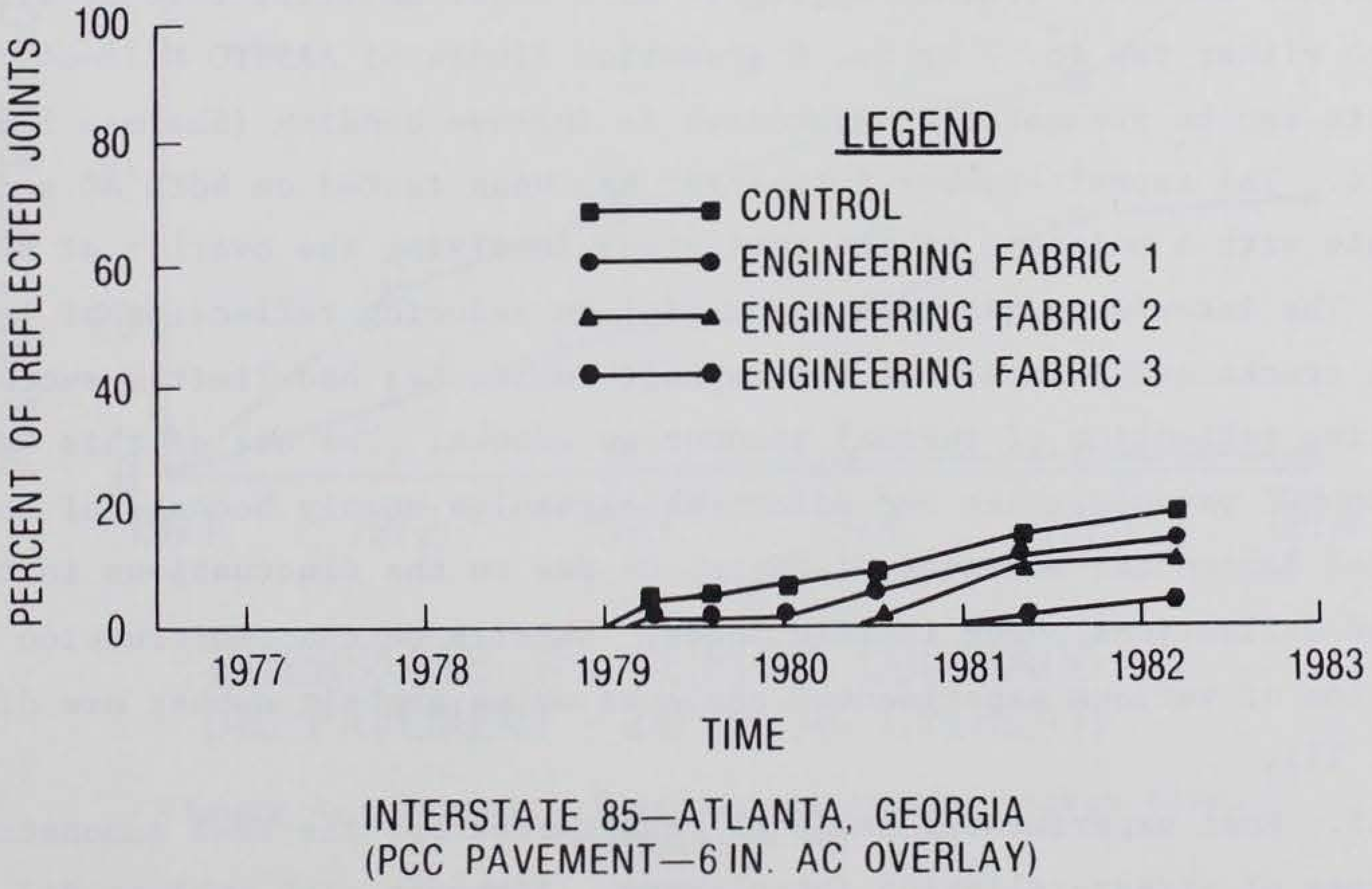


Figure 3. Percent of reflected joints versus time, 6-in. AC overlay

12. The engineering fabric interlayers have been used extensively over AC pavements throughout the country. Many different types of fabric and various construction procedures have been demonstrated and have had varying results. The states with mild climates, such as California, Florida, Mississippi, and Texas, have had mostly favorable results, and states with cold climates, including Colorado, Maine, Vermont, and Wyoming, have had unsatisfactory results (Sherman 1982). Details on the construction and evaluation of various experimental projects using the engineering fabrics are discussed in Part III.

13. The use of asphalt rubber as a stress-relieving interlayer has been researched extensively by the DOT and highway departments of many states with the Arizona DOT leading the way (Morris and McDonald 1976; Way 1976, 1979). Two types of asphalt rubber have been used as a SAMI for the rehabilitation of pavements. One asphalt-rubber mixture is a combination of vulcanized rubber (20 to 25 percent), paving asphalt (75 to 80 percent), and an extender oil (1 to 5 percent). The other mixture is a combination of asphalt cement, rubber, and possibly an extender oil with approximately the same proportions, but the rubber is composed of a blend of powdered devulcanized rubber (40 percent) and powdered vulcanized rubber (60 percent). Both of these asphalt-rubber mixtures use a clean, crushed aggregate as a cover material that usually conforms to either the No. 7 or No. 8 gradation limits of AASHTO M 78-64. The aggregate can be preheated or precoated to improve bonding (Sherman 1982).

14. The asphalt-rubber interlayer has been tested on both AC and PCC pavements with a majority of the test sites involving the overlay of AC pavements. The interlayer has been successful in reducing reflection of longitudinal cracks and joints, but the asphalt rubber has had limited success in preventing reflection of thermal transverse cracks. The use of this interlayer on PCC pavements has had unfavorable results mainly because of the differential horizontal movement of the slabs due to the fluctuations in temperature and deflections under traffic loads. Details on the construction and evaluation of various experimental projects using asphalt rubber are discussed in Part III.

15. Most experimental projects constructed for the FHWA demonstrated both types of stress-relieving interlayers. Although each project did not contain the same characteristics such as condition of existing pavement, pavement preparation, and climatic conditions, each project was designed to

evaluate the performance of these interlayers with respect to a standard hot-mix overlay. In most cases this evaluation was based on the percent of cracks reflecting through an overlay as a function of time. Data from various experimental projects are shown in Figures 4 through 7 and Tables 1 through 3 (Anderson 1983a, 1983b; Gulden 1982; Sherman 1982; Vedros 1981).

16. The success of these interlayers has varied from state to state and from job to job. Some items that appear to have had a profound effect on the performance of an overlay are thickness, the amount of crack sealing and pavement preparation before overlaying, and the geographic location of the pavement. The interlayers that have performed favorably tend to be located in warm and mild climates while interlayers that have performed unfavorably tend to be located in cold climates. These findings agree with the conclusions reported in an earlier report by Vedros (1981).

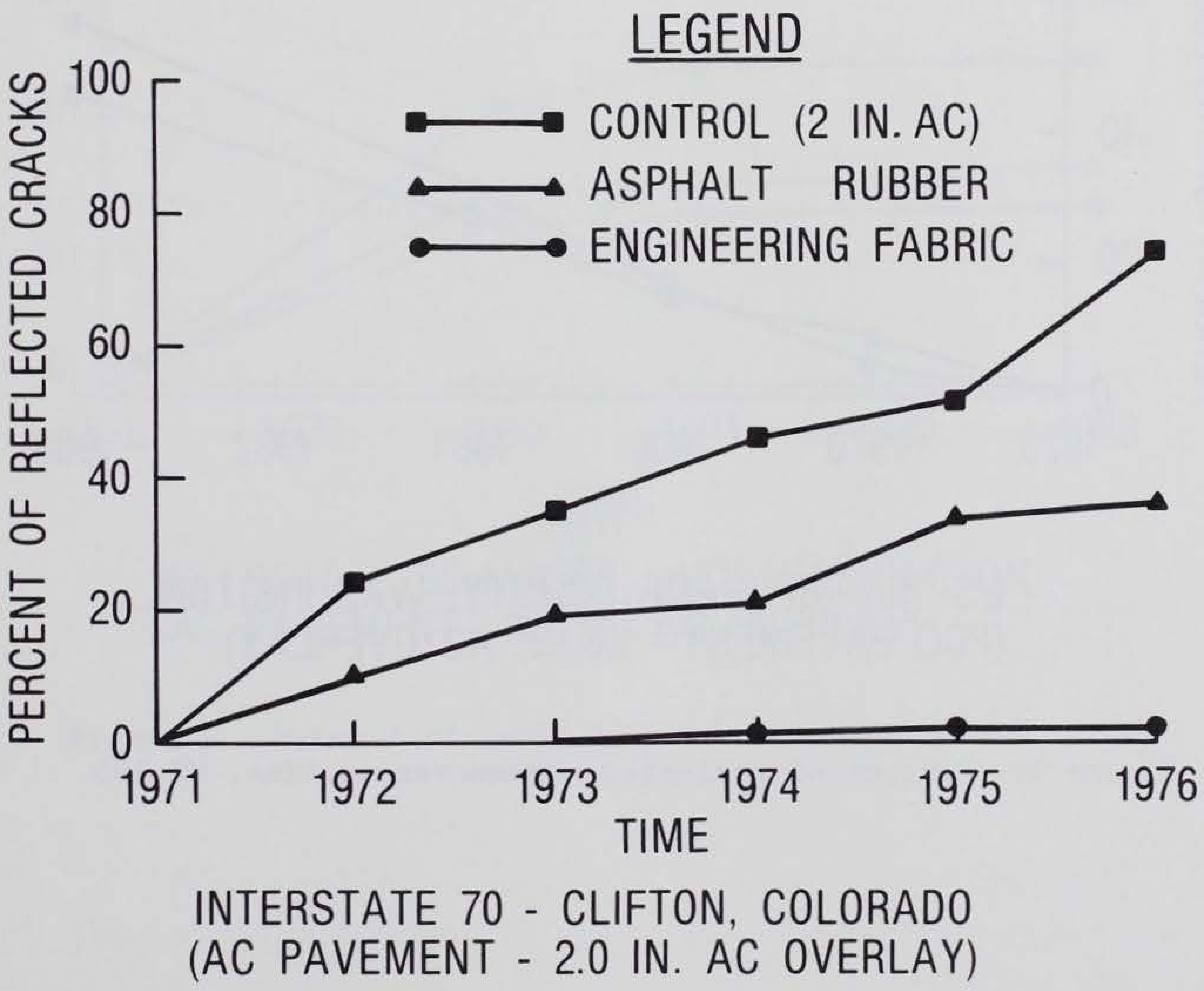


Figure 4. Percent of reflected cracks versus time, Interstate 70

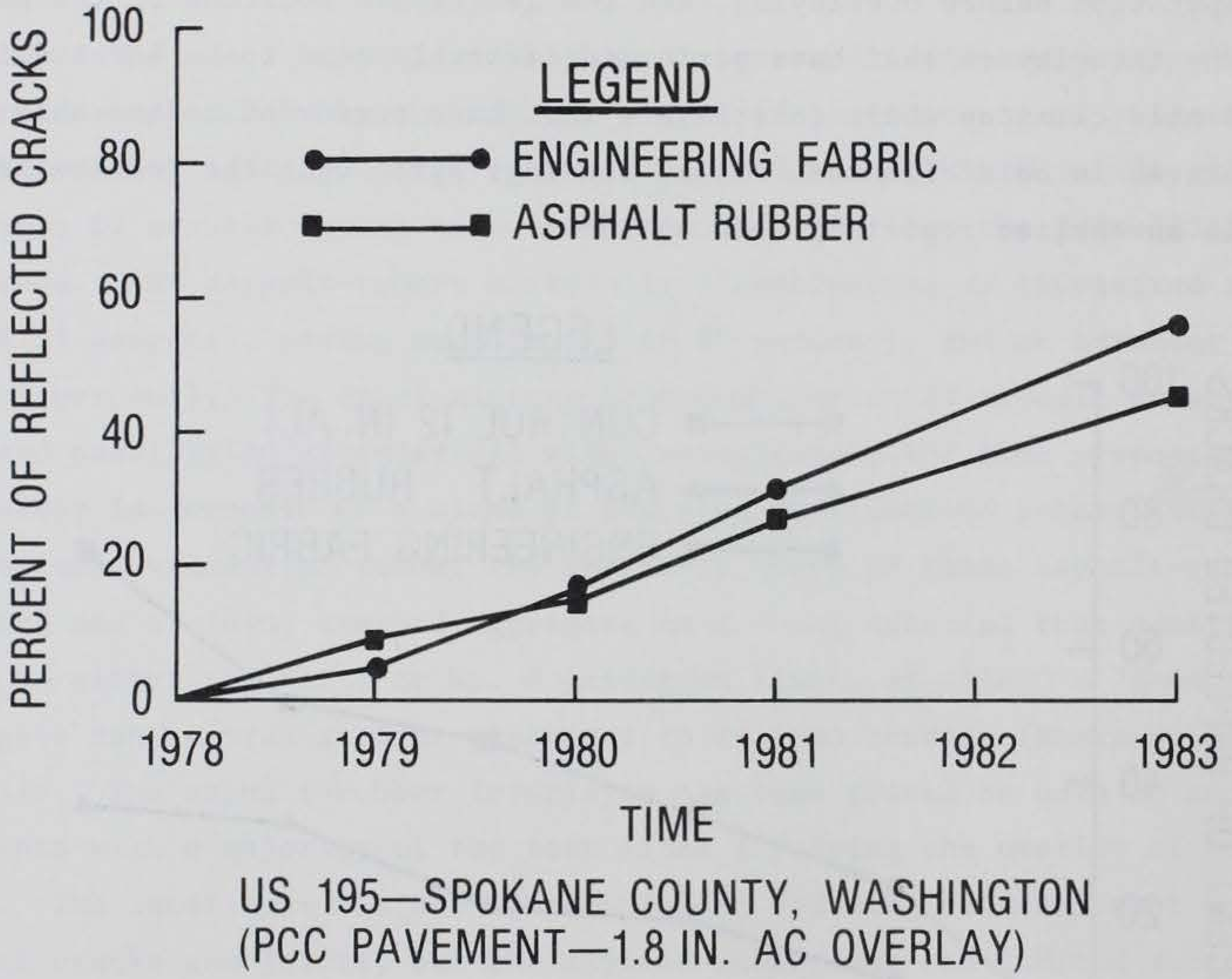


Figure 5. Percent of reflected cracks versus time, US 195

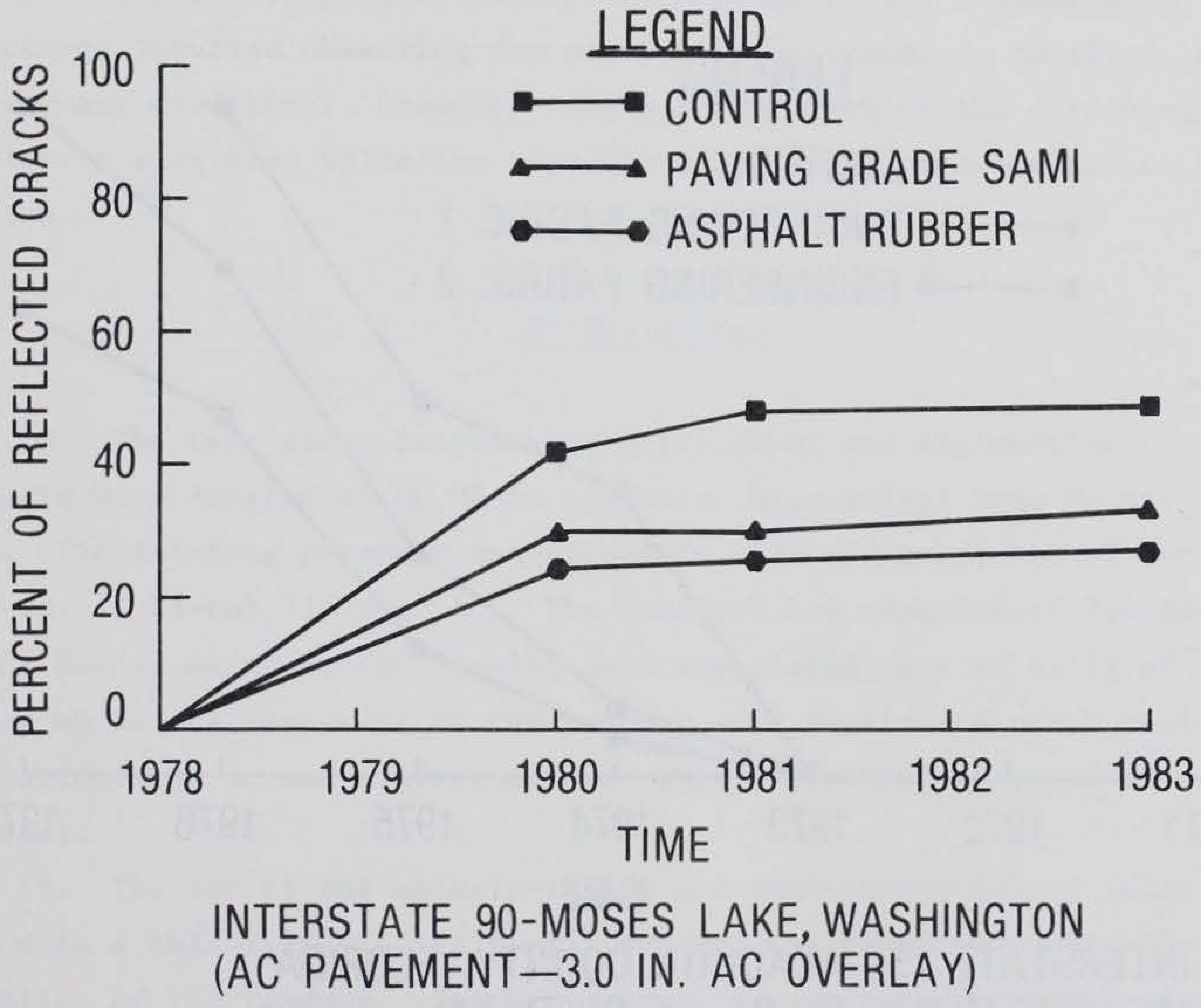


Figure 6. Percent of reflected cracks versus time, Interstate 90

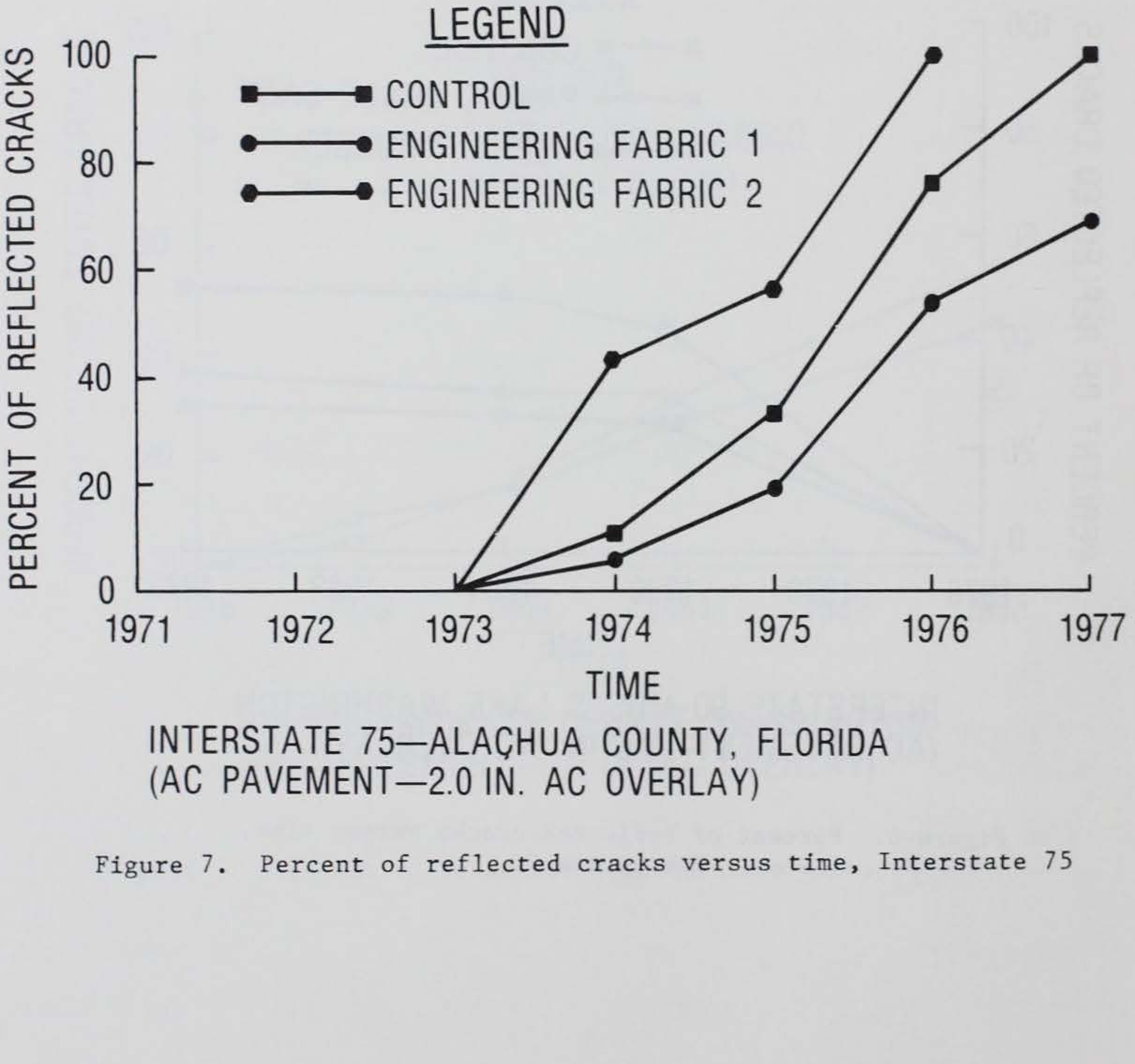


Figure 7. Percent of reflected cracks versus time, Interstate 75

PART III: FIELD INSPECTIONS

17. From the literature survey, a collection of information on various current experimental evaluation projects was obtained. These test sites along with specific construction data are shown in Table 4. Visual inspections of the pavements were made at the following sites: US 98, McComb, Miss.; US 12, Walla Walla, Wash.; Kannah Creek, Grand Junction, Colo.; Alameda Avenue, Denver, Colo.; US 2, Spokane, Wash.; and Cottage Grove, Urbana, Ill. These inspections involved observing the pavements for cracking, raveling, and overall pavement condition. Comments on the performance of the stress-relieving interlayers were also solicited from the engineering personnel at each location.

US 98, McComb

18. The test sites for both asphalt-rubber and engineering fabric interlayers were located on US 98 in southwest Mississippi near McComb (Kidd 1981). The existing pavement was placed in 1972 and consisted of three 1-1/2-in. (3.81-cm) lifts of AC. The pavement had experienced fatigue cracking and needed maintenance. A slag seal was placed on a majority of the roadway while the remainder of the project site received a crack sealing application. After one winter, many of the cracks had reflected through the slag seal.

19. The use of the asphalt-rubber and engineering fabric interlayers along with a thin 1-1/2-in. (3.81-cm) overlay was recommended for the rehabilitation of the roadway. Neither a leveling course nor crack sealant was used prior to the rehabilitation process. Due to variations in the existing pavement and in the crack widths, the project was divided into two portions. The first portion, which contained wide cracks, was used to compare the two types of asphalt rubber while the remainder of the roadway, which had received a slag seal the year before, was used to compare the performance of the two asphalt rubbers and an engineering fabric with a standard control section of 1-1/2-in. (3.81-cm) AC overlay. These various methods resulted in six test sections and were completed during the summer of 1980.

20. In each of the six test sections, a 1,000-ft (304.8 m) section was selected for evaluation. The cracks were measured and mapped in each section

prior to the rehabilitation process. Each year since the construction of the overlay, the evaluation sections have been mapped to determine the percentage of cracks reflecting through the overlay. The percentage of cracks reflecting through an overlay as a function of time for each treatment is shown in Figure 8. The engineering fabric and asphalt-rubber interlayers have reduced the reflective cracking, especially during the first 3 years of the overlay. Even though there was an increase in reflective cracking during 1983-1984, reflective cracking in the interlayer sections was still averaging 45 percent less than the control section after 4 years.

21. A visual inspection was conducted in March 1984, 4 years after the interlayers were placed. There was a noticeable difference between the

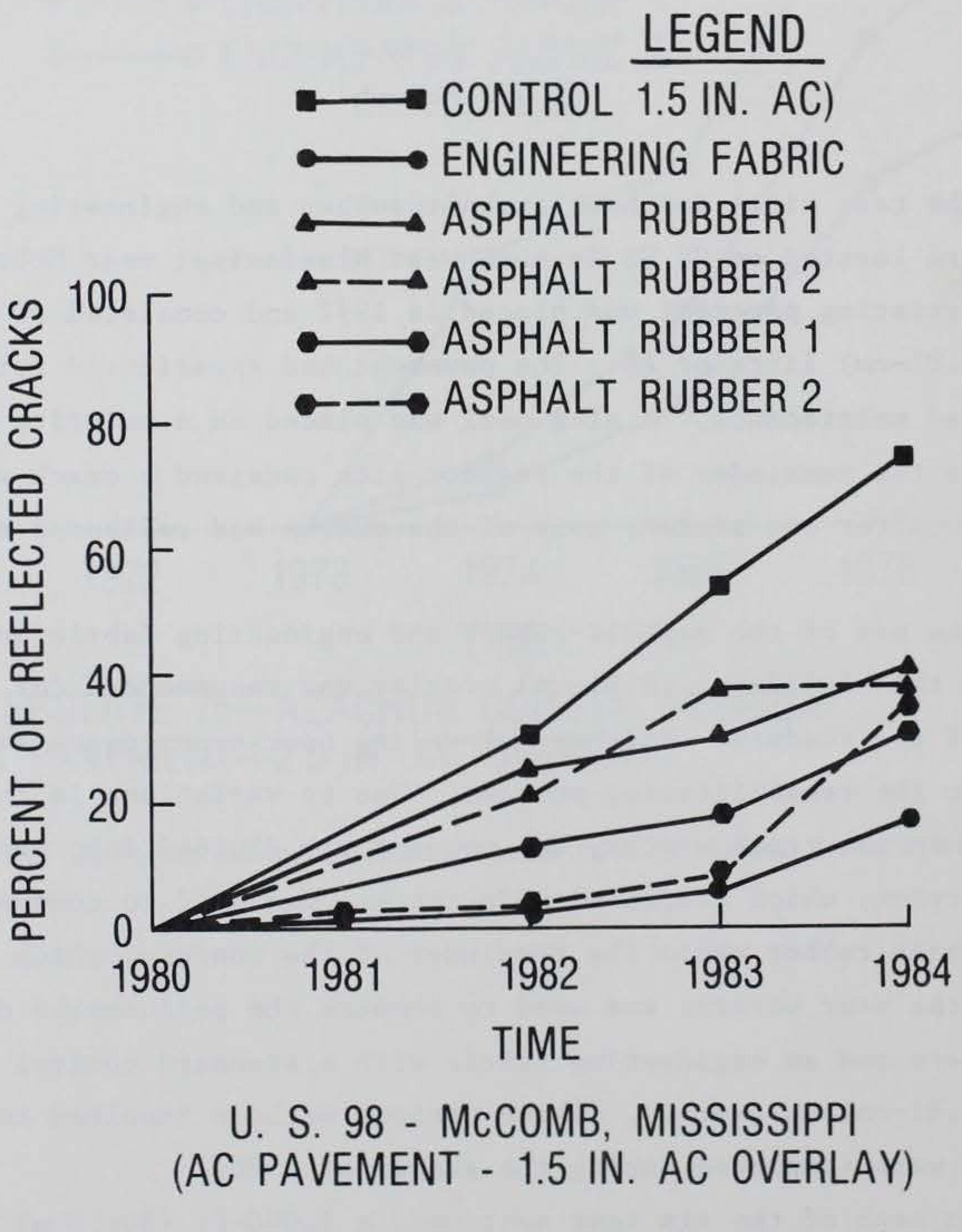


Figure 8. Percent of reflected cracks versus time, US 98

pavements which had been maintained with different maintenance techniques prior to the rehabilitation process (Figure 9). The asphalt-rubber interlayer which was placed over the wide crack section was not reducing the reflective cracks as well as the asphalt-rubber interlayer over the slag seal section. At the time of the inspection in 1984, a majority of the rehabilitation techniques had retarded the propagation of reflective cracks. Compared with the control section, the asphalt-rubber and engineering fabric sections were performing very well (Figures 10 through 12). The project engineer was satisfied with the results of the interlayer and stated that the engineering fabric was a better interlayer for the money for this project.

US 12, Walla Walla

22. This project which is located on US 12 near Walla Walla, Wash., was designed to evaluate the effectiveness of an engineering fabric interlayer with a thin overlay (Gietz 1981). The original pavement was a PCC pavement that had been rehabilitated with a 6-in. (15.24-cm) layer of crushed stone and a 3-in. (7.62-cm) AC overlay. After years of service, the wearing surface contained cracking and rutting. The cracks in this overlay averaged 1/4 in. (0.635 cm) in width and were located throughout the project. Due to the deterioration of the pavement, resurfacing, using a procedure to control reflective cracking, was recommended.

23. Construction of this AC overlay was similar to that used by a majority of state highway departments. All existing cracks wider than 1/8 in. (0.3175 cm) were sealed prior to the application of the tack coat, an AR-4000 asphalt cement. The engineering fabric was placed immediately behind the distributor and followed by the paving operation. The overlay thickness was 1.8 in. (4.57 cm). This construction was completed in June 1980.

24. For the first 3 years, the engineering fabric rated excellent in preventing reflective cracking, but after the fourth winter, the engineering fabric section began showing cracks similar to that in the control section. During the inspection conducted in 1984, it was noticed that the control and fabric sections contained about the same number of cracks; however, the engineering fabric section contained tighter cracks (Figures 13 and 14). The percentage of cracks reflecting through the overlay for each treatment is shown in Figure 15. According to the Washington State DOT representative, the

Figure 9. Comparison of asphalt-rubber interlayers, wide crack section (background), and slag seal section (foreground)

Figure 10. Control section, US 98, McComb

Figure 11. Engineering fabric section, US 98, McComb

Figure 12. Asphalt-rubber section, US 98, McComb

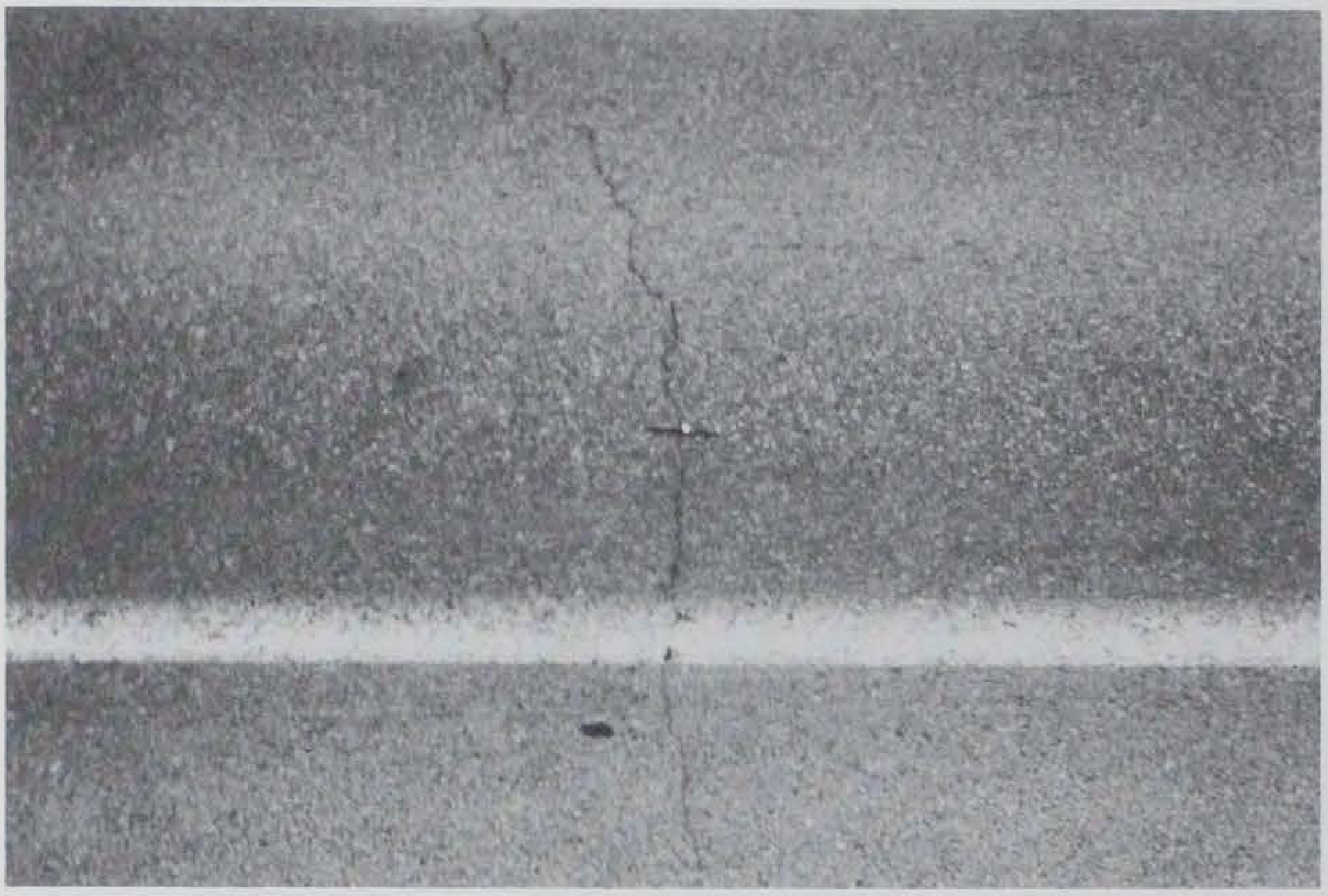


Figure 13. Engineering fabric section, US 12, Walla Walla

Figure 14. Control section, US 12, Walla Walla

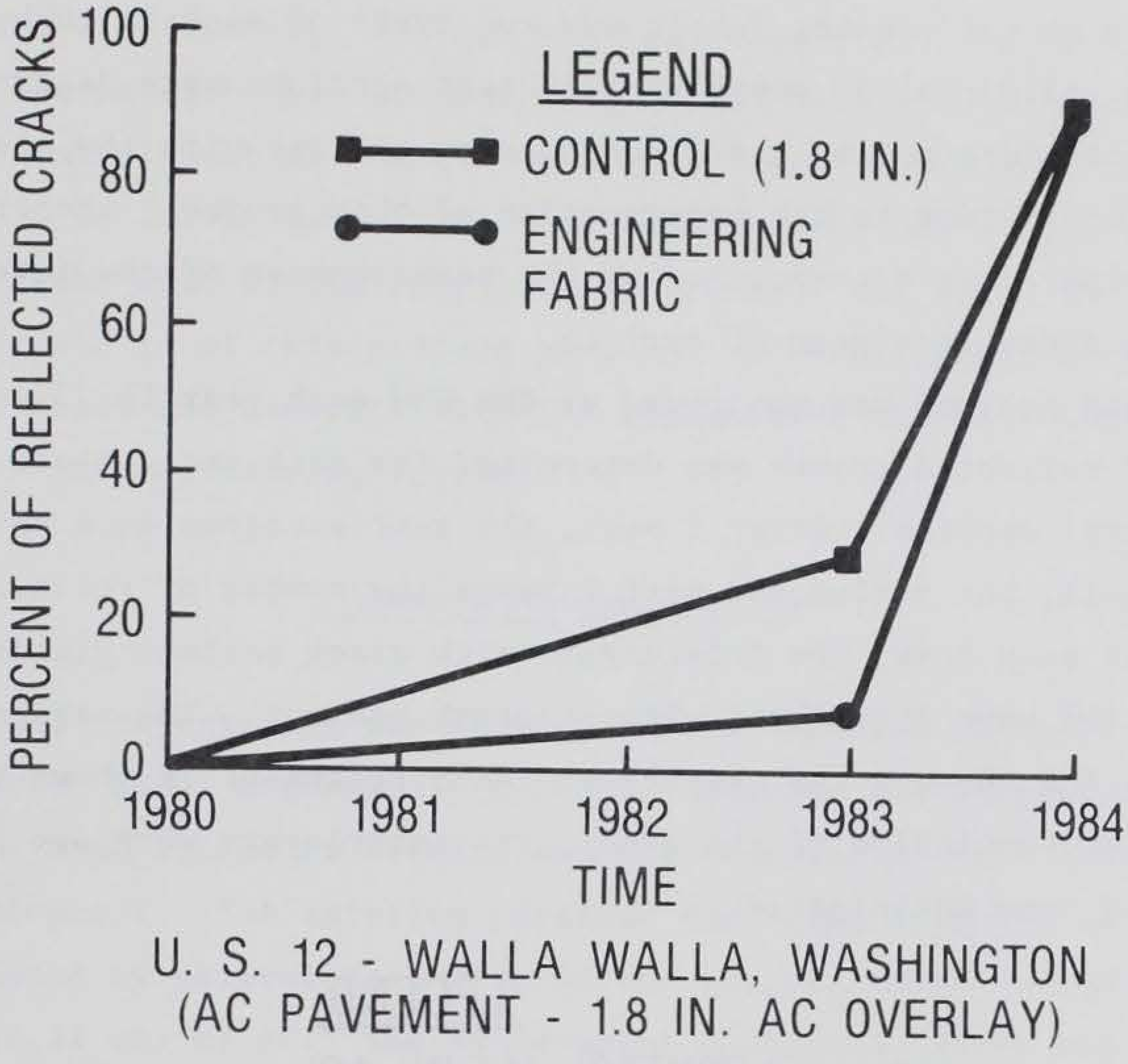


Figure 15. Percent of reflected cracks versus time, US 12

engineering fabric section was not performing as well as it had been prior to the winter of 1983-84. The 1983-84 winter season in Walla Walla was one of the coldest on record.

Kannah Creek, Grand Junction

25. The test site was constructed on US 50 southeast of Grand Junction, Colo., for the purpose of evaluating stress-relieving interlayers (Swanson, LaForce, and Donnelly 1980). The AC pavement was inspected in 1977, and the inspection indicated that the pavement was structurally sound but badly cracked. The pavement surface was in need of restoration, but, due to the severity of the thermal cracks and the possibility of the cracks reflecting through the pavement, a thin overlay of AC could not be used. With the encouragement of the FHWA, the Colorado Department of Highways (CDH) demonstrated the use of asphalt-rubber and engineering fabric interlayers as a means of minimizing reflective cracking.

26. The construction of this project, which began in July 1977, included placing an engineering fabric and two types of asphalt rubber with a thin 1-1/2-in. (3.81-cm) AC overlay. The test sections were designed to compare the interlayers with and without crack sealant with the standard overlay section. Prior to the construction of this project, the cracks were measured in order that a comparison of the performances of the interlayers could be made after each year of service.

27. This project was monitored by the CDH each year for 3 years. A percentage of reflected cracks was determined for each section and compared with the control section. After 1 year, the test sections as a whole performed very well, but during the next 2 years the number of reflective cracks increased. In each case, the interlayers with crack sealant yielded better results than the same interlayer without crack sealant. The percentage of cracks reflecting through the overlay for each treatment is shown in Figure 16. At the conclusion of the study, the interlayers were not performing as well as had been anticipated.

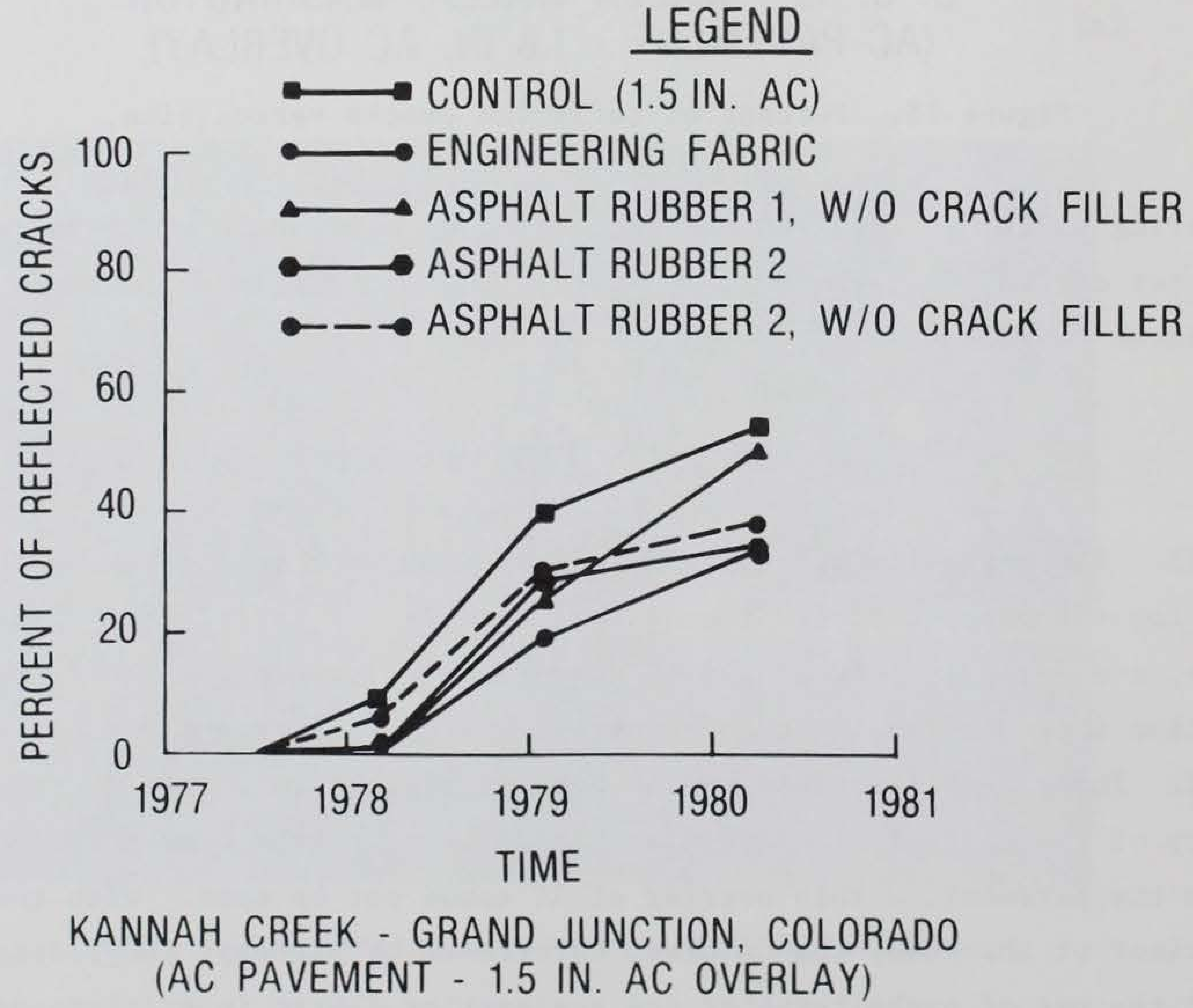


Figure 16. Percent of reflected cracks versus time, Kannah Creek

28. The visual inspection was conducted in April 1984, 7 years after the construction of the test section had been completed. At the time of this inspection, the pavement was excessively cracked with no noticeable difference between the control section and the other sections. The cracks were randomly spaced 3 to 15 ft (0.914 to 4.57 m) apart, and a majority of the cracks were transverse cracks with widths ranging from 1/2 to 1 in. (1.27 to 2.54 cm). Although the results of this project were not favorable, engineers for the CDH believe that there are benefits with the application of these interlayers, especially with the engineering fabric.

Alameda Avenue, Denver

29. This project site was located in urban Denver on West Alameda Avenue, Colorado State Highway 26 (LaForce, Swanson, and Donnelly 1980). The roadway had a high volume of traffic and was occupied on both sides by commercial development. The existing pavement consisted of a PCC pavement that had been widened by several feet with AC and overlaid with approximately 6-1/2 in. (16.51 cm) of AC. The AC pavement contained severe cracking in the extended portions of the pavement, probably caused by inadequate support underneath the AC, while only longitudinal and transverse cracking existed above the PCC pavement.

30. The rehabilitation techniques used in this demonstration project included an engineering fabric and an asphalt-rubber interlayer. Due to the conditions of the existing pavement, an additional overlay would not provide satisfactory performance. Before the reflective cracking treatments could be placed, 3 in. (7.62 cm) of AC pavement was removed with a cold-milling machine. After cold milling, the remaining cracks were filled with asphalt-rubber crack sealant. The application of the stress-relieving interlayers was similar to that of other projects with the engineering fabric and asphalt rubber being placed directly on the milled surface and overlaid with 1-1/2 in. (3.81 cm) of AC. These reflective crack treatments were installed in September 1976.

31. The test sections were measured prior to construction so that a percentage of reflective cracks could be determined for each yearly inspection. For the first year, all of the sections were effective in preventing the reflective cracks, but, during the second winter, the reflective cracks

increased with the control sections having over half the cracks reflecting through the overlay while the sections with interlayers had about a third of the cracks reflecting through the overlay. At the end of the third year, the control section had 75 percent, and the interlayer sections had 50 percent reflection cracking. The percentage of reflection cracking as a function of time is shown in Figure 17. The poor performance of these treatments can be contributed to base failures.

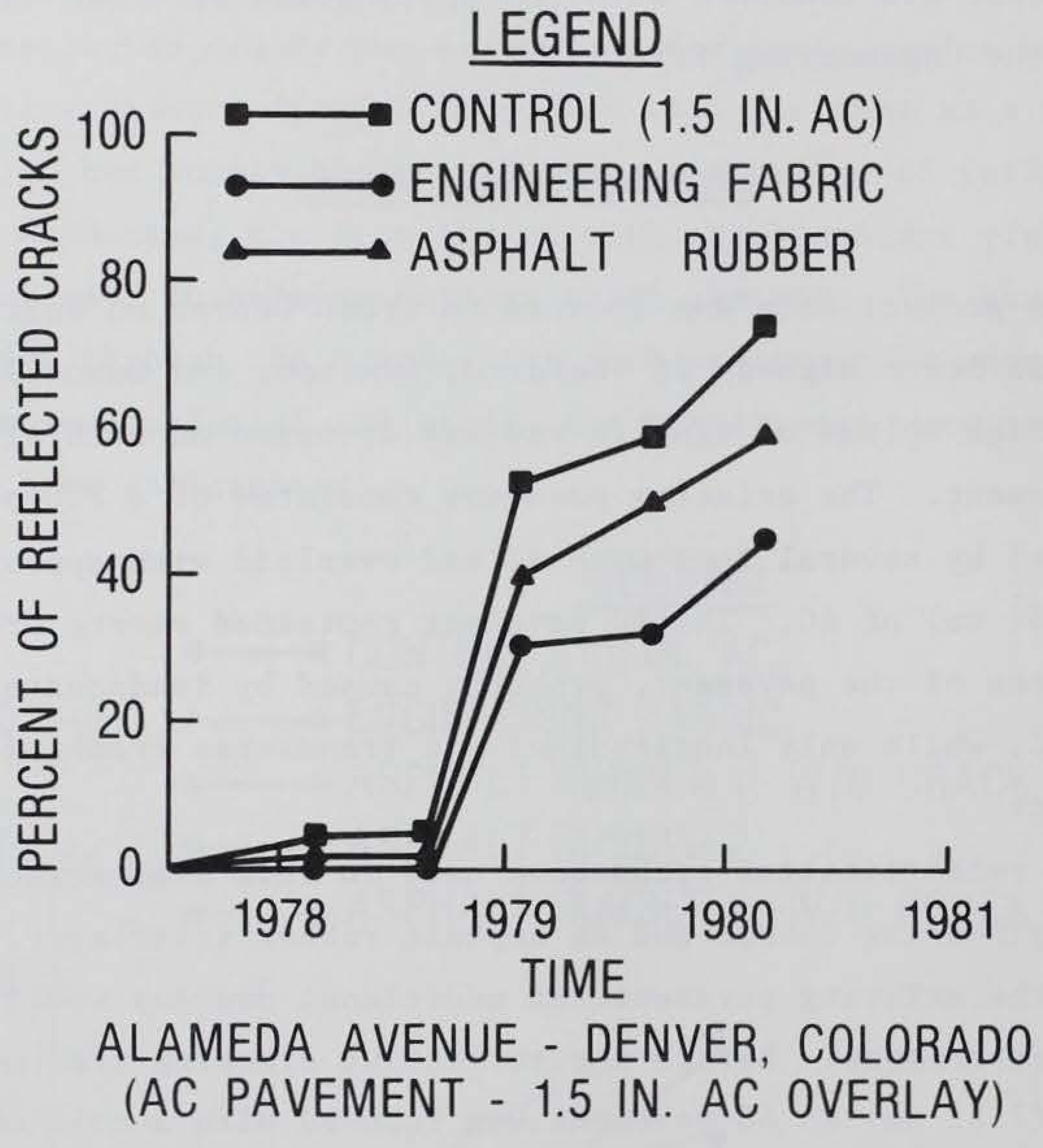


Figure 17. Percent of reflected cracks versus time, Alameda Avenue

32. A visual inspection was conducted by the author in April 1984, 7 years after construction of the project. The test sections looked very similar; however, the asphalt-rubber section had fewer and tighter cracks. Alligator cracking had occurred in each section in the outside lanes. Since the last state inspection in 1980, the ability of the stress-relieving interlayers to reduce and retard the reflective cracks has decreased. Figures 18 and 19 are typical examples of the pavement condition after 7 years of service.

Figure 18. Alligator cracking in outside lane, Alameda Avenue, Denver

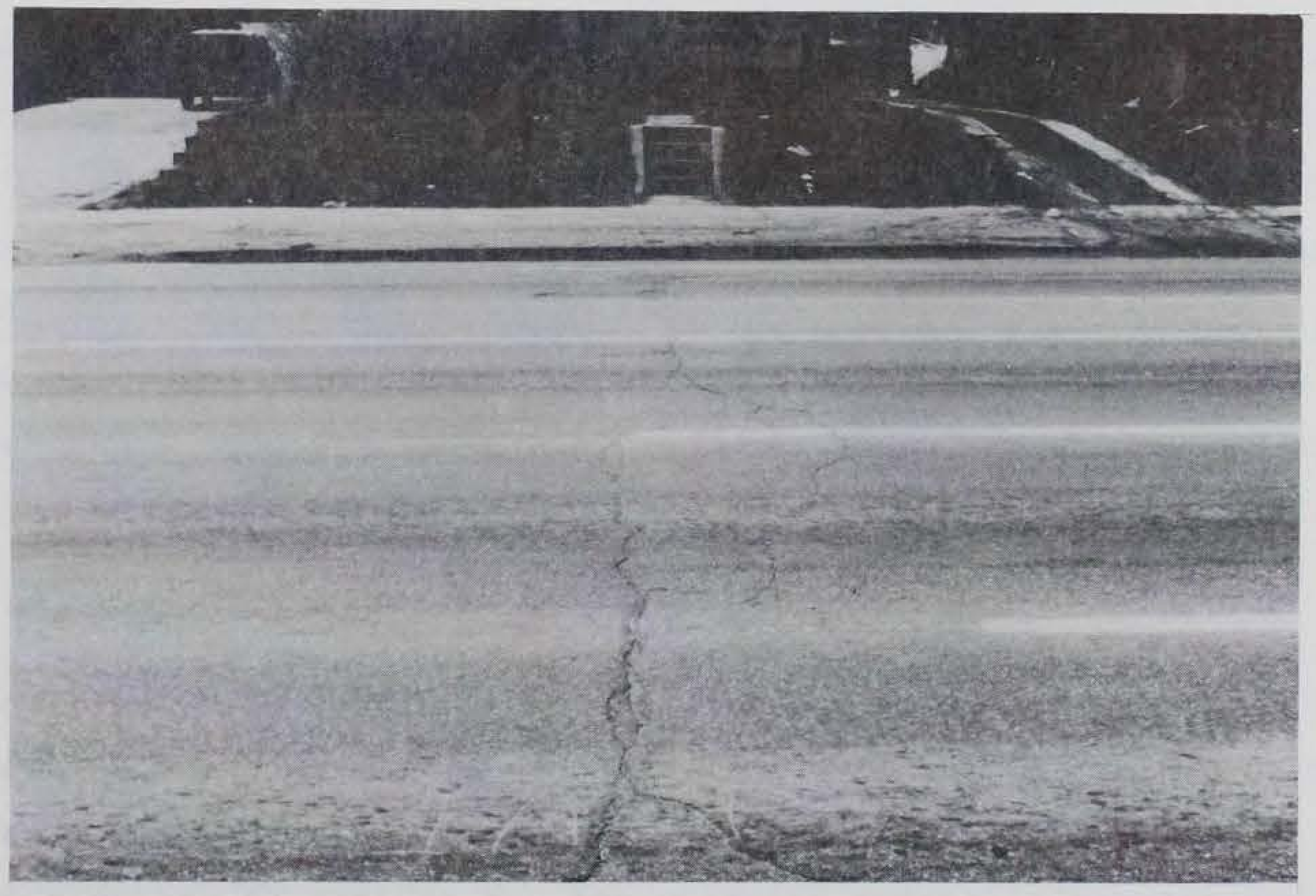


Figure 19. Engineering fabric section, Alameda Avenue, Denver

US 2, Spokane

33. This experimental installation is located on US 2 north of Spokane, Wash. (Anderson 1983c). The resurfacing project, which consisted of placing an asphalt-rubber interlayer and a thin 1.8-in. (4.57-cm) AC overlay was completed in July 1978. The existing pavement consisted of PCC pavement which had been widened and resurfaced with AC and an AC pavement with an untreated stone base. The pavement had experienced fatigue cracking in the AC pavement, and reflective cracking was evident over the PCC pavement.

34. In this project the preconstruction cracks were not measured or mapped, so an actual percentage of reflective cracks could not be determined. Instead, a percentage was based on the assumption that the section originally had transverse cracks at 15-ft (4.51-m) intervals and longitudinal cracks which totaled three times the length of the test section. Although this is not an actual number for reflective cracking, the percentages can be used to determine the yearly increase and are shown in Table 5. The results shown were very encouraging because of the slow yearly increase throughout the 5 year period.

35. The field inspection was conducted in April 1984, 6 years after the installation of the reflective crack treatment. At the time of inspection, the interlayer was functioning very well controlling reflection cracks from the underlying pavement. The cracks in the test section over the PCC pavement were reflecting through approximately every 30 ft (9.14 m) while transverse cracks were appearing every 100 ft (30.48 m) in the AC portion. Typical cracking of this pavement is shown in Figures 20 and 21. According to the Washington State DOT, the asphalt-rubber interlayer has been a success.

Cottage Grove Road, Urbana

36. The test installation was located on Cottage Grove Road in Urbana, Ill., (Mascunna 1981). The existing pavement of this city street consisted of 2-1/2 in. (6.35 cm) of AC with a 7-in. (17.78-cm) aggregate base. The pavement had experienced alligator cracking and was subject to unstable subgrade. The rehabilitation of this roadway involved installation of an engineering fabric and construction of two 1-in. (2.54-cm) lifts of AC surface course. This rehabilitation technique was installed in July 1975.

Figure 20. Typical transverse crack over original PCC pavement, US 2, Spokane County

Figure 21. Typical transverse crack over original AC pavement, US 2, Spokane County

37. This project was monitored for 5 years to determine the effectiveness of the fabric interlayer. At the end of 16 months, the engineering fabric and control sections were performing very well with only random fine cracks. After 2 years of service, the differences in the number and widths of cracks became apparent. The control section developed more than twice as many cracks as did the fabric interlayer section. The fabric interlayer section had also reduced the size of the cracks. After 5 years of service, the number of cracks had increased in both sections, but the severity and number of cracks in the fabric section were less.

38. The visual inspection was conducted in April 1984, 9 years after the installation of the engineering fabric. The roadway as a whole was in good condition. Although there were a large number of cracks in the pavement (Figures 22 and 23), the pavement structure was sound. It appeared that the engineering fabric interlayer had reduced and retarded some of the cracking and had also aided in waterproofing the subgrade.

Figure 22. Longitudinal crack in engineering fabric section, Cottage Grove Road, Urbana

Figure 23. Wide transverse crack in engineering fabric section, Cottage Grove Road, Urbana

PART IV: DATA ANALYSIS AND RESULTS

39. Although there has been a great deal of research concerning asphalt-rubber and engineering fabric interlayers, a standard procedure for determining the effectiveness of these interlayers has not been developed. Evaluation of the performance of interlayers for most projects was based on the percentage of cracks that reflected through the overlay from the existing pavement. A comparison was generally made for a period of years between sections containing the interlayers and a control section. Using reflective crack data and a system for determining success or failure of an interlayer, the effectiveness of the interlayers was established.

40. Since the geographic location and climate had a significant influence on the effectiveness of the interlayers, a geographic boundary for the use of these interlayers was developed. In order to determine whether an interlayer had been successful or not, a simple rating scale was used. For all sections that had less than 60 percent reflective cracks after 5 years, these interlayers were considered to have favorable or satisfactory results, and all interlayers that had more than 60 percent reflective cracks after 5 years were considered to be unsatisfactory and unfavorable. In cases where no reflective crack data were obtained, the rating of a pavement was based on the conclusions determined by that particular highway department. The results of the acquired data were plotted for the engineering fabric on both AC and PCC pavements (Figures 24 and 25), and the results of the asphalt rubber on AC pavements were plotted in Figure 26.

41. Using the figures for the AC pavements and the mean freezing index chart (Figure 27) from TM 5-812-2 (Headquarters, Department of the Army 1983), a geographic boundary was developed for the use of interlayers to minimize reflective cracking. Figure 28 shows a map of the United States which is divided into three areas. Area I is the section of the country that has a mean air freezing index below 0. Area II is the portion that has a mean air freezing index between 0 and 500, and Area III is the northern region with a mean air freezing index above 500.

42. These areas are not permanent and can vary for a particular site because changing temperature conditions can alter the mean air freezing index. The boundaries alone are not to be used for decision making but as guidelines for the use of the interlayers. Based on this investigation, pavements in

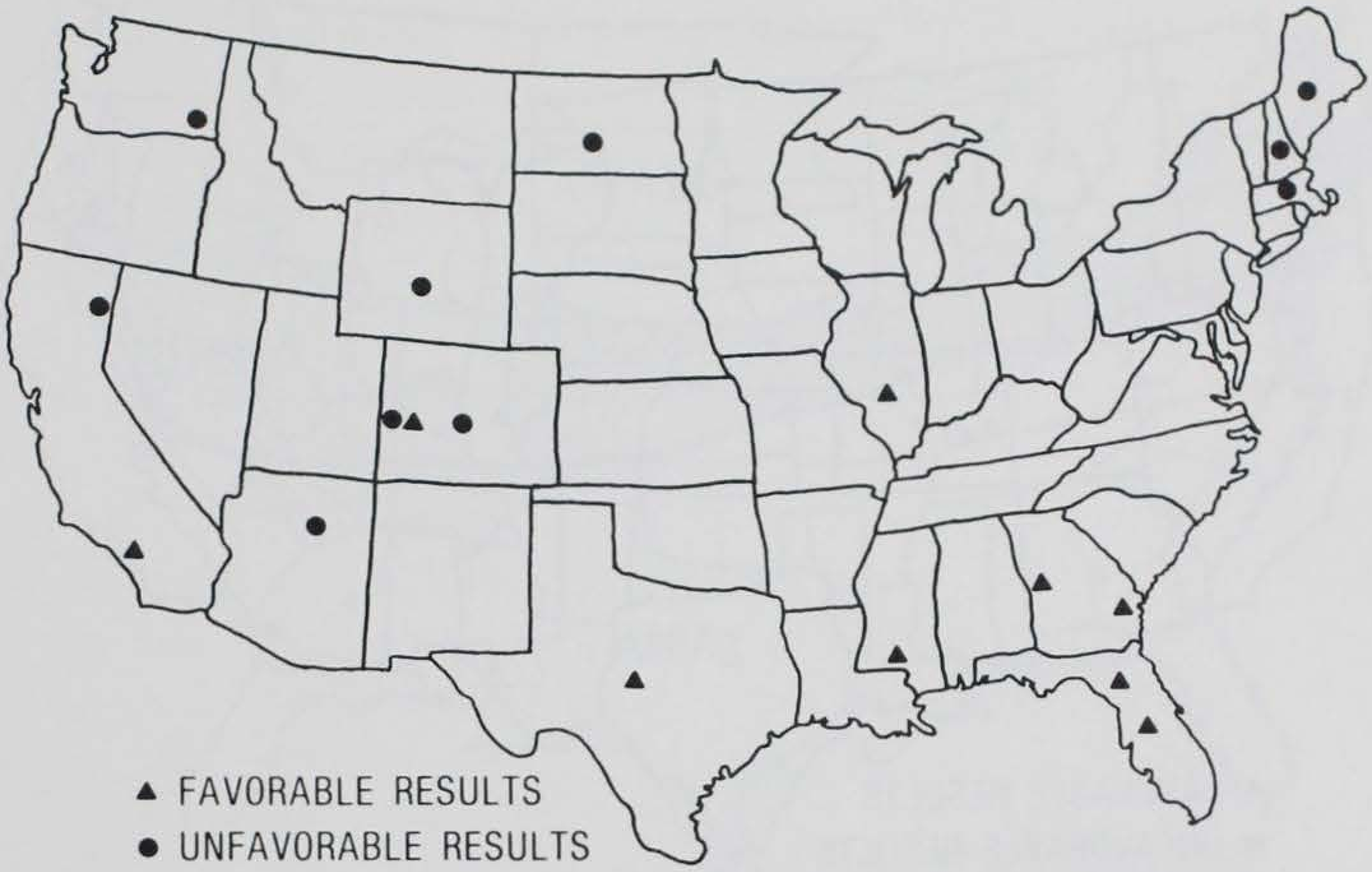


Figure 24. Results of engineering fabric interlayers over AC pavements

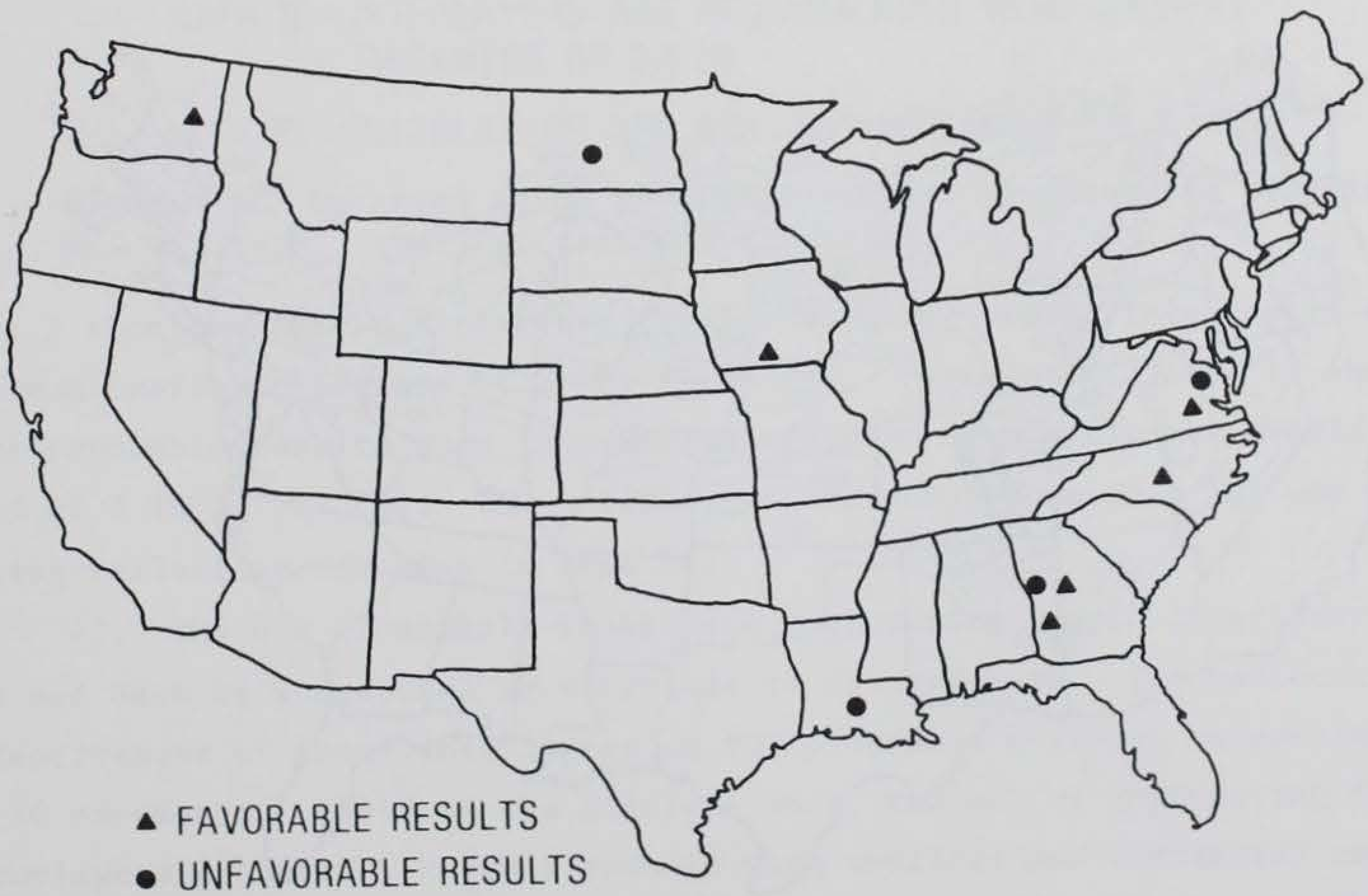


Figure 25. Results of engineering fabric interlayers over PCC pavements

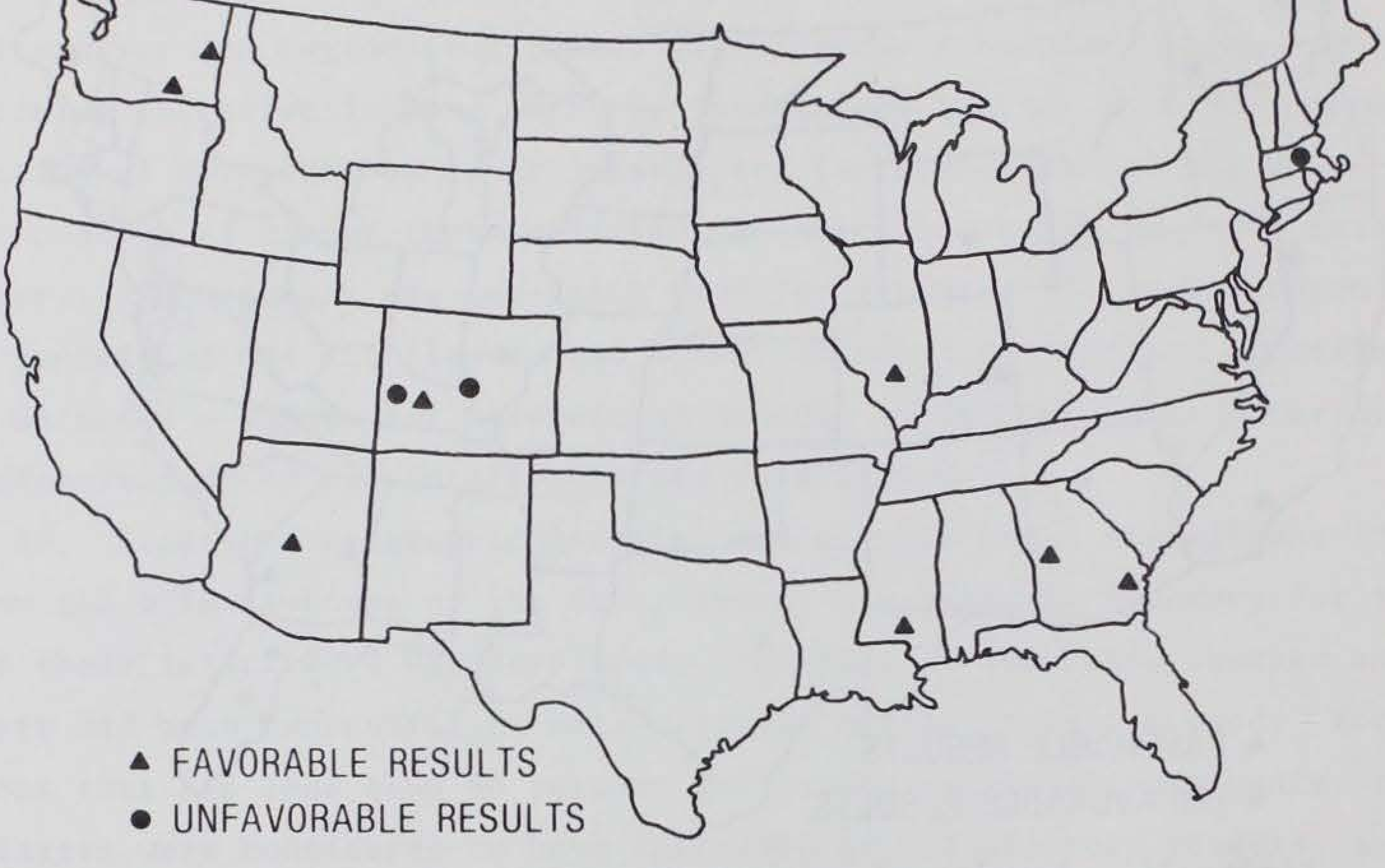


Figure 26. Results of asphalt-rubber interlayers over AC pavements

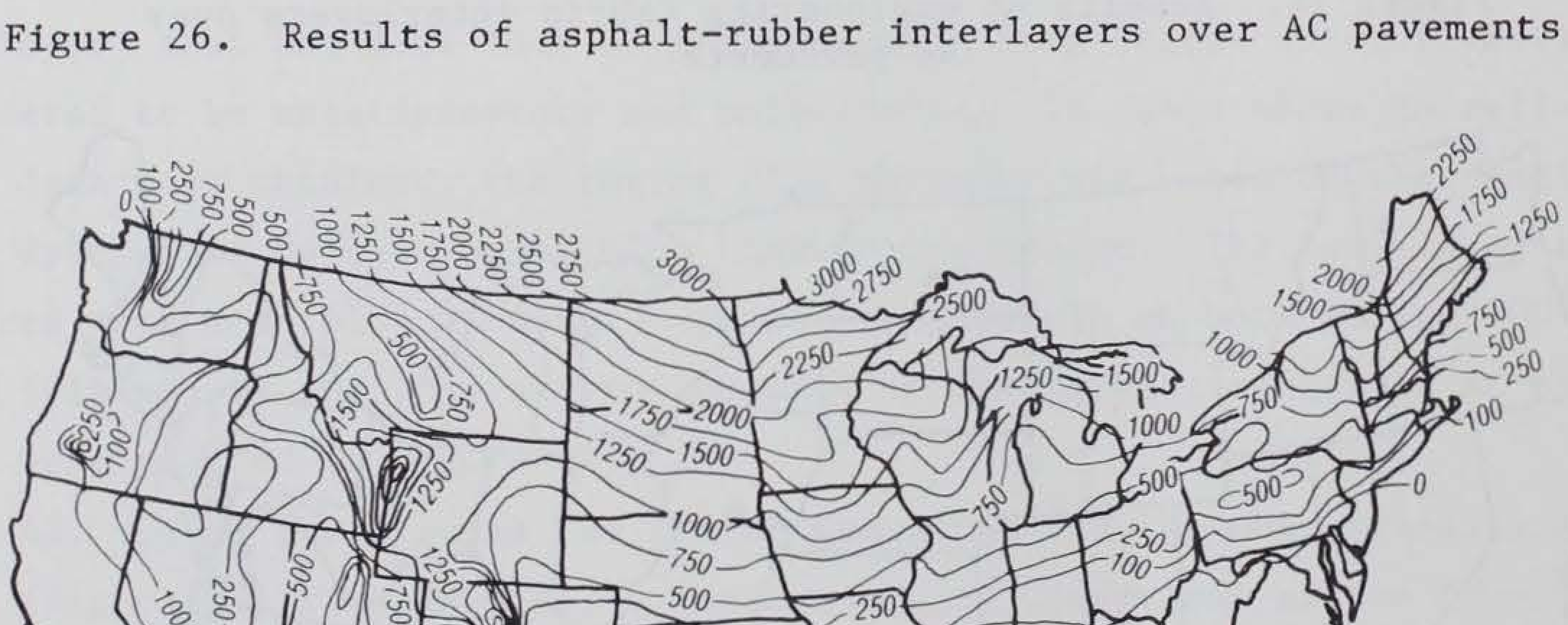


Figure 27. Distribution of mean air freezing index values in continental United States

AREA I - INTERLAYERS ARE RECOMMENDED WITH MINIMUM OVERLAY THICKNESS OF 2 IN.

AREA II - INTERLAYERS ARE RECOMMENDED WITH OVERLAY THICKNESS OF 3-4 IN.

AREA III - INTERLAYERS ARE NOT RECOMMENDED.

Figure 28. Location guide for overlaying AC pavements to minimize reflective cracking

Area I should obtain satisfactory results with the use of interlayers and a minimum overlay thickness of 2 in. (5.08 cm). Pavements in Area II should have favorable results when interlayers are used with a minimum overlay thickness of 3 in. (7.62 cm). The interlayers are not recommended for use in reducing reflective cracking in Area III.

43. The use of asphalt-rubber and engineering fabric interlayers on PCC has not been as widespread as their use on AC pavements. The performance and effectiveness of these interlayers on PCC pavements were not as conclusive as on AC pavements. Based on the acquired data, the use of engineering fabric interlayers achieved favorable results when vertical and horizontal movements of the slabs were kept to a minimum and, in the case of the Georgia DOT, when a 4-in. (10.16-cm) overlay thickness was used. The climate and geographic location affect interlayer performance in a manner similar to those on AC

pavements with favorable results generally occurring in warm climates and unfavorable results occurring in cold climates. Due to the poor performance and an inadequate data base, the use of asphalt-rubber interlayers to minimize the reflection of joints on PCC pavements is not recommended.

PART V: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

44. The asphalt rubber and engineering fabric are two methods that can be used to retard but not prevent reflective cracking in AC overlays. These interlayers can retard the cracks from reflecting upward when there is proper preparation of the existing pavement and when a proper thickness of overlay is used. These preventive measures also decrease the size of the cracks in addition to minimizing the amount of water penetrating into the base course and subgrade. Lower maintenance costs and extended service life are the major benefits which can be achieved with the use of the asphalt-rubber and engineering fabric interlayers.

Recommendations

45. Based on the data obtained in this investigation, the following recommendations are given as guidelines to obtain the maximum usage of interlayers and to maximize the long-term performance of the pavement.

Overlay of AC (engineering fabric)

46. The existing pavement should be relatively smooth and structurally sound with all cracks larger than 1/8 in. (0.3175 cm) sealed. A leveling course is often needed before the full-width application of the fabric to ensure a suitable surface. The minimum recommended overlay thickness is 2 in. (5.08 cm) in Area I and 3 in. (7.62 cm) in Area II. This technique is not recommended for use in Area III.

Overlay of PCC (engineering fabric)

47. The engineering fabric can be used as a fabric strip or a full-width application. The existing pavement should be structurally sound with negligible movement under loads, and all joints and cracks larger than 1/8 in. (0.3175 cm) sealed. The strip method is applied directly on the PCC pavement joints and cracks and then overlaid. A leveling course is often needed before the application of the full-width method. The minimum recommended overlay thickness is 4 in. (10.16 cm) in Areas I and II. This technique is not recommended for use in Area III.

Overlay of AC (asphalt rubber)

48. The existing pavement should be structurally sound, and cracks larger than 1/4 in. (0.635 cm) should be sealed. The thickness of the SAMI should range from 0.35 to 0.75 in. (0.89 to 1.27 cm). The minimum recommended overlay thickness is 2 in. (5.08 cm) in Area I and 3 in. (7.62 cm) in Area II. This technique is not recommended for use in Area III.

Overlay of PCC (asphalt rubber)

49. The application of the asphalt-rubber interlayer is not recommended for use on PCC pavements. Additional test data are needed before the performance of the application can be evaluated.

REFERENCES

Anderson, K. W. 1983a. "Rubber-Asphalt Binder Stress-Absorbing Membrane Interlayer," Report No. 178, Washington State Department of Transportation, Olympia, Wash.

__________. 1983b. "Rubber-Asphalt Binder Stress-Absorbing Membrane Interlayer," Report No. 187, Washington State Department of Transportation, Olympia, Wash.

__________. 1983c. "SAMI and Heavy Duty Bituthene Reflection Crack Prevention Study," Report No. 186, Washington State Department of Transportation, Olympia, Wash.

Gietz, R. H. 1981. "Post-Construction Report on Fabric Reinforcement," Report No. 172, Washington State Department of Transportation, Olympia, Wash.

Gulden, W. 1982. "Evaluation of Asphalt-Rubber Seal Coats and Interlayers for Rehabilitation of Flexible Pavements," Report No. FHWA/GA-82/004, Georgia Department of Transportation, Atlanta, Ga.

Gulden, W., and Brown, D. 1983. "Treatments for Reduction of Reflective Cracking of Asphalt Overlays on Jointed-Concrete Pavements in Georgia," Transportation Research Record 916, Transportation Research Board, Washington, DC.

Headquarters, Department of the Army. 1983. "Pavement Design for Seasonal Frost Conditions" (in preparation), TM 5-812-2, Washington, DC.

Kidd, S. Q. 1981. "Asphalt Rubber Stress-Absorbing Membrane Interlayers, Demonstration Project No. 37," FHWA-DD-37-17, Mississippi State Highway Department, Jackson, Miss.

LaForce, R. F., Swanson, H. N., and Donnelly, D. E. 1980. "Reflection Cracking Treatments Alameda Avenue Project MU 0026(2)," Colorado Department of Highways, Denver, Colo.

Mascunna, I. 1981. "An Evaluation of Engineering Fabric in Pavement Rehabilitation (IHD-21)," Physical Research Report No. 88, Illinois Department of Transportation, Springfield, Ill.

McGhee, K. H. 1975. "Efforts to Reduce Reflective Cracking of Bituminous Concrete Overlays of Portland Cement Concrete Pavements," Virginia Highway and Transportation Research Council, Charlottesville, Va.

Morris, G. R., and McDonald, C. H. 1976. "Asphalt-Rubber Stress-Absorbing Membranes: Field Performance and State of the Art," Phoenix, Ariz.

Sherman, G. 1982. "Minimizing Reflection Cracking of Pavement Overlays," Transportation Research Board, Washington, DC.

Swanson, H. N., LaForce, R. F., and Donnelly, D. E. 1980. "Reflection Cracking Evaluation Kannah Creek, Colorado Project FC 050-1(8)," Colorado Department of Highways, Denver, Colo.

Vedros, P. J., Jr. 1981. "Evaluation of Membrane Interlayers for Prevention of Crack Reflection in Thin Overlays," Miscellaneous Paper GL-81-8, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Way, G. B. 1976. "Prevention of Reflective Cracking in Arizona Minnetonka-East (A Case Study)," Arizona Department of Transportation, Phoenix, Ariz.

_________. 1979. "Prevention of Reflective Cracking Minnetonka-East (1979 Addendum Report)," Arizona Department of Transportation, Phoenix, Ariz.

BIBLIOGRAPHY

Button, J. W., and Epps, J. A. 1982. "Evaluation of Fabric Interlayers," FHWA/TX-83/6+261-2, Texas Transportation Institute, College Station, Tex.

Carey, D. E. 1975. "Evaluation of Synthetic Fabrics for the Reduction of Reflective Cracking," Research Project No. 70-1B(B), Louisiana Department of Highways, Baton Rouge, La.

Dykes, J. W. 1980. "The Use of Fabric Interlayers to Retard Reflective Cracking," Proceedings, Association of Asphalt Paving Technology, Minneapolis, Minn., Vol 49, pp 354-368.

Jackson, R. D. 1980. "Use of Fabrics and Other Measures for Retarding Reflective Cracking of Asphalt Concrete Overlays," Miscellaneous Paper GL-80-2, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Muncaster, J. W. 1984. "Pavement Geotextiles in the United States," International Conference on Geotextile Technology, London, England.

Swanson, H. N. 1983. "Evaluation of Reflection Cracking in Bituminous Overlays on Concrete Pavements," Report No. CDOH-DTP-R-83-12, Colorado Department of Highways, Denver, Colo.

US Army Engineer District, Alaska. 1982. "Fabric Reinforced Asphalt on Runways to Reduce Reflective Cracking," Anchorage, Alaska.

Vedros, P. J., Jr. 1979. "Evaluation of the Effectiveness of Membranes for Prevention of Crack Reflection in Thin Overlays," Miscellaneous Paper GL-79-4, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Table 1

Summary of Performance of Test Sections at Fort Stewart

Section No.	Test Material	Original Length of Cracks, ft*	Percent of Cracks Reflected May 1978	Aug 1979	Apr 1980	Jun 1981	Section Average
1	Asphalt rubber 1	101.8	0	0	0	2.0	1.0
2	Asphalt rubber 1	108.0	0	0	0	0	
3	Asphalt rubber 2	132.0	0	0	13.6	30.9	31.0
4	Asphalt rubber 2	145.0	0	16.4	31.3	31.3	
5	Engineering fabric 1	126.0	0	5.0	16.3	24.3	42.6
6	Engineering fabric 1	132.0	0	26.5	35.8	60.8	
7	Engineering fabric 2	138.0	29.7	37.0	48.6	63.1	56.9
8	Engineering fabric 2	120.0	8.3	19.9	33.6	50.7	
9	Control	131.9	0	0	0	0	9.1
10	Control	99.0	0	0	0	18.1	

* 1 ft = 0.3048 m.

Table 2

Summary of Performance of Test Sections at Fort Devens

Section No.	Test Material	Original Length of Cracks, ft*	Percent of Cracks Reflected Jun 1978	Aug 1979	Jun 1980	Jun 1981
1	Asphalt rubber 1	154.0	0	34.4	34.4	44.8
2	Control	88.0	0	49.9	49.9	50.0
3	Engineering fabric 1	92.0	0	54.4	60.2	85.2
4	Engineering fabric 2	161.0	0	33.8	41.3	48.6
5	Control	118.0	0	70.7	70.7	78.0
6	Asphalt rubber 2	69.0	0	27.5	74.9	88.8
7	Asphalt rubber 2	94.0	0	25.5	31.3	73.1
8	Control	73.0	0	66.7	66.7	67.4
9	Engineering fabric 1	57.0	0	29.5	38.6	76.5
10	Engineering fabric 2	43.0	0	65.6	84.0	97.0
11	Asphalt rubber 1	84.0	0	58.3	58.8	67.5
12	Control	99.0	0	26.3	28.3	39.1
13	Engineering fabric 1	79.0	0	61.4	62.2	62.2
14	Engineering fabric 2	90.0	0	32.8	46.4	46.4
15	Asphalt rubber 2	84.5	0	37.3	41.0	48.8
16	Asphalt rubber 1	130.0	0	20.2	39.6	39.6
17	Control	122.5	0	37.0	37.1	57.5
18	Asphalt rubber 2	65.0	0	0	0	8.9
19	Asphalt rubber 1	60.0	0	9.8	15.2	33.0
20	Engineering fabric 2	69.0	0	12.2	14.8	60.4
21	Engineering fabric 1	48.0	0	16.3	23.5	57.9
22	Control	80.0	0	0	0	30.5

* 1 ft = 0.3048 m.

Table 3

Reflective Cracking as Percent of Original Condition

R-20 Cherokee County

Type Treatment	Evaluation Date Dec 1976	Jun 1977	Feb 1978	Sep 1980	Jun 1982
Asphalt rubber, sections 1-10	0	0	2	9	35
Engineering fabric 1	0	0	0	12	12
Engineering fabric 2	0	1	8	*	*
Engineering fabric 3	0	0	0	45	104
Engineering fabric 4	0	0	0	0	4
Asphalt rubber, sections 27-31	0	0	0	0	12
Control	0	0	10	**	**
Asphalt rubber, west of river	--	--	--	0	13

* Entire section resurfaced due to slippage problems and fatigue failure.
** Resurfaced when topping was placed over asphalt-rubber interlayer west of Etowah River.

Table 4

List of Test Sites

Site No.	Location	Original Pavement	Interlayers	Overlay Thickness in.*	Date Constructed	Mean Freezing Index
1	US 12 - Walla Walla, Washington	AC	Fabric	1.8	May 1980	100
2	US 20 - Cherokee Co., Georgia	AC	Fabric	1.5	September 1976	0
3	US 98 - McComb, Mississippi	AC	Asphalt rubber Fabric	1.5	May 1980	0
4	Alameda Avenue - Denver, Colorado	AC	Asphalt rubber Fabric	1.5	September 1976	250
5	US 50 - Grand Junction, Colorado	AC	Asphalt rubber Fabric	1.5	August 1977	375
6	Fort Devens, Massaschusetts	AC	Asphalt rubber Fabric	2.0	October 1977	300
7	Interstate 70 - Clifton, Colorado	AC	Asphalt rubber Fabric	+2.0	August 1971	375
8	Interstate 75 - Alachua Co., Florida	AC	Fabric	2.0	August 1971	0
9	Fort Stewart, Georgia	AC	Asphalt rubber Fabric	1.5	October 1977	0

(Continued)

* 1 in. = 2.54 cm.

(Sheet 1 of 3)

Table 4 (Continued)

Site No.	Location	Original Pavement	Interlayers	Overlay Thickness in.*	Date Constructed	Mean Freezing Index
10	Interstate 94 - Buffalo, North Dakota	AC	Fabric	1.5	August 1972	2,250
11	US 2 - Spokane, Washington	AC	Asphalt rubber Fabric	1.8	July 1978	200
12	Interstate 90 - Moses Lake, Washington	AC	Asphalt rubber	3.0	June 1978	250
13	US 195 - Spokane, Washington	PCC	Asphalt rubber Fabric	1.8	August 1978	200
14	Interstate 85 - Gwinnett Co., Georgia	PCC	Fabric	2.0 4.0 6.0	August 1976	0
15	Interstate 85 - Troup Co., Georgia	PCC	Fabric	2.0 4.0	August 1979	0
16	US 70 - Orange Co., North Carolina	PCC	Fabric	2.0	July 1978	0
17	Interstate 25 - Denver, Colorado	PCC	Asphalt rubber	0.75	September 1978	250
18	US 61 - Sorrento, Louisiana	PCC	Fabric	3.5	March 1971	0

(Continued)

* 1 in. = 2.54 cm.

Table 4 (Concluded)

Site No.	Location	Original Pavement	Interlayers	Overlay Thickness in.*	Date Constructed	Mean Freezing Index
19	Interstate 95 - Alexandria, Virginia	PCC	Fabric	1.5	July 1972	0
20	Route 460 - Sussex Co., Virginia	PCC	Fabric	1.25	August 1971	0
21	Cottage Grove Road - Urbana, Illinois	AC	Fabric	2.0	July 1975	100
22	Interstate 40 - Winslow, Arizona	AC	Asphalt rubber Fabric	1.5	June 1972	50
23	Interstate 15 - Riverside, California	AC	Fabric	1.0	1972	0

* 1 in. = 2.54 cm.

(Sheet 3 of 3)

Table 5

Crack Data for US 2, Spokane, Washington

Station Limits	Cracking Length, ft*			
	1979	1980	1981	1983
0+00 - 10+00	830	921	996	1,179
10+00 - 20+00	525	564	625	819
20+00 - 30+00	483	648	666	737
30+00 - 40+00	546	546	597	729
40+00 - 50+00	611	629	704	749
50+00 - 60+00	646	715	772	813
60+00 - 70+00	834	961	1,117	1,309
70+00 - 80+00	673	710	849	852
80+00 - 90+00	522	536	559	632
90+00 - 100+00	822	857	933	1,099
100+00 - 110+00	984	1,026	1,170	1,207
110+00 - 119+48	287	297	344	379
Total	7,763	8,410	9,332	10,504
Percent of maximum**	12.3	13.4	14.8	16.7

* 1 ft = 0.3048 m.

** Maximum based on transverse crack interval of 15 ft plus longitudinal crack length equal to three times the section length. Maximum = 62,946 ft.