PORTLAND CEMENT CONCRETE PAVEMENT RESTORATION

By

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FINAL REPORT

Under the Supervision
of

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16. ABSTRACT

The purpose of this study was to evaluate the design, construction, and performance of the latest methods for restoration of Portland cement concrete pavements (PCCP). The CPR techniques demonstrated included full depth repair, spall repair, undersealing, restoration of load transfer, diamond grinding, and the resealing of all joints.

This is the final evaluation of the project.

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TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

The Oklahoma Department of Transportation hosted an FHWA Tri-Regional Pavement Rehabilitation Conference in Oklahoma City, Oklahoma, on May 14-17, 1984. In conjunction with the conference, CPR (Concrete Pavement Restoration) methods were demonstrated on a 1,500 foot section of I-40 west of Yukon, as part of the FHWA Demonstration Project No. 69 "Portland Cement Concrete Pavement Restoration".

The purpose of this study was to evaluate the design, construction, and performance of the latest methods for restoration of Portland cement concrete pavements (PCCP). The CPR techniques demonstrated included full depth repair, spall repair, slab stabilization, retrofit of load transfer devices, diamond grinding, and resealing of pavement joints.

A video tape documenting the construction phase of the project was prepared, and is available for those interested.

The project has been evaluated on a yearly basis since 1984. This report summarizes and provides conclusions based on the information obtained during the construction phase and the yearly evaluations through 1987.

TEST SITE

In February, 1984, the FHWA approached ODOT with the opportunity of hosting a Tri-regional Pavement Rehabilitation Conference including a field demonstration of PCC pavement restoration techniques. It was predetermined that the field demonstration was to be located in proximity to the conference which would take place at the Hilton Inn West, in Oklahoma City. Hence, a visual survey of the Interstate system within a 30 mile radius was conducted to determine which areas would qualify as a test section. In particular, pavements which had faulted joints, cracked slabs, and exhibited signs of active pumping were considered to be ideal for pavement restoration.

Preliminary investigation of these areas, including fault measurements and deflection readings, resulted in the selection of a 2,400 foot section on eastbound I-40, between Yukon and El Reno. This section, originally built in 1969, consists of a 9 inch plain PCC pavement with sawed joints every 15 feet on a 4 inch fine aggregate bituminous base (FABB). The top 6 inches of the subgrade had been modified with lime. The typical section of the roadway is illustrated in Figure 1.

Although the percentage of truck traffic has increased since original construction, the 1984 ADT was 42 percent below the original projection for 1985. The traffic design data at the time of construction and at the time of restoration are shown in Figure 2.

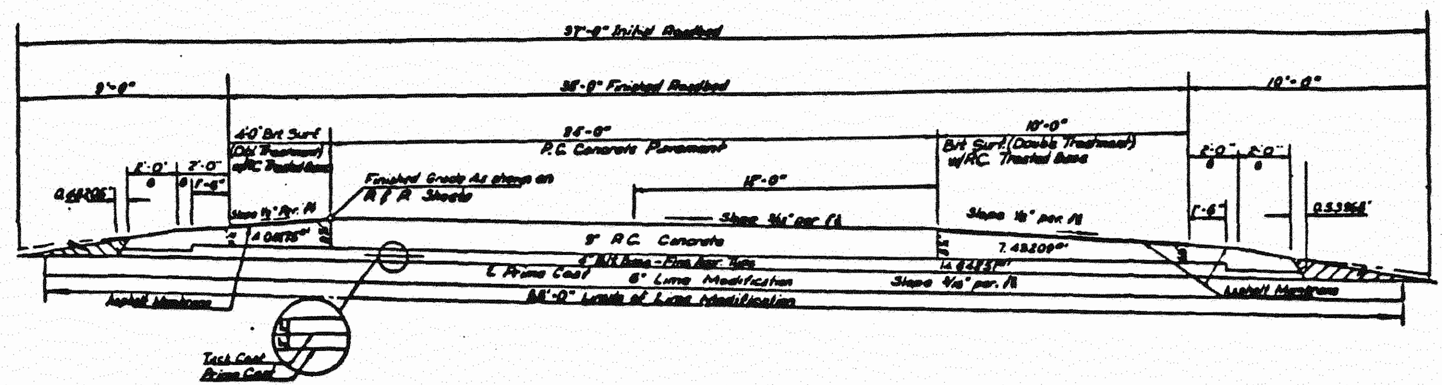

Figure 1. Typical section of I-40 test section.

DESIGN DATA

1969		1984	
ADT-1965	=13,000	ADT-1984	=21,000
ADT-1985	=36,000	ADT-2004	=38,000
DHV	= 3,960	DHV	= 3,800
D	= 55%	D	= 55%
T(% OF ADT)	= 10%	T(% OF ADT)	= 18%
V	=70 MPH	V	=70 MPH

Figure 2. Traffic design data - I-40 test section.

CONDITION SURVEY

A general condition survey was performed on the selected site. The results can be summarized as the following:

1. The pavement exhibited faulting which measured up to a half inch.
2. The deflections were all 0.02 inches or smaller as measured under an 18,000 lb. axle load.
3. Two slabs in the inside lane had large corner breaks.
4. A wide longitudinal crack spanned three consecutive slabs in the outside lane.
5. The shoulders were distressed and had been patched along the longitudinal joint.
6. Cores taken indicated a wet base, but there was no evidence of stripping.
7. One joint was spalled.
8. The Mays ride meter data indicated a need for corrective measures.

RESTORATION TECHNIQUES

The restoration of this section of I-40, including the Demonstration, was completed in 7 working days. All work was subject to daylight operations with traffic being maintained on the adjacent lane, and the section was completely opened to traffic from 7:00 p.m. to 7:00 a.m. With these constraints, the work proceeded as follows:

- Day 1 Removal and replacement of slabs in the inside lane.
- Day 2 Removal and replacement of slabs in the outside lane, spall repair and non-destructive testing.
- Day 3 Slab stabilization of the outside lane.
- Day 4 Installation of load transfer devices and diamond grinding in the outside lane.
- Day 5 Demonstration.
- Day 6 Joint sealant installed in outside lane.
- Day 7 Joint sealant installed in inside lane.

Although this was the general order, several operations were performed over consecutive days and also repeated for the demonstration. There were no delays for weather, and traffic flow was virtually uninterrupted.

Full Depth Repair

Five slabs were identified as being cracked and in need of repair. Two slabs in the inside lane had relatively large corner breaks, and three consecutive slabs in the outside lane possessed a wide longitudinal crack that spanned all three slabs. In each case, the cracks were too wide to be sealed. Due to the severity and the extent of the cracking, full depth removal and replacement was chosen in lieu of full depth patching.

Beginning early in the morning, the slabs were removed, and the base was cleaned. Dowel bars were installed in the existing adjacent slabs. Dowel baskets were used for the intermediate joints of the consecutive slabs. The fresh concrete was placed and finished by early afternoon. Utilizing Air-Entrained High Early Strength Concrete, the pavement was opened to traffic by 7:00 p.m.

After three years of service, there are no signs of distress.

Spall Repair

A spall located across a joint was repaired with a polymer concrete using the partial depth replacement technique. The area around the spall was sawed to a depth of 2 inches to provide clean vertical edges. The damaged concrete was chipped out with a jack hammer and sand blasted clean. Tape was applied to the longitudinal joint as a bond breaker, and a piece of plywood was used to form the transverse joint. A primer coat was applied and then the polymer concrete was placed. After the concrete hardened, the plywood was removed.

One year after installation, it appeared that the polymer concrete had debonded around the edges. However, the patch did not appear to be loose. After three years of service, the polymer concrete patch is still in place and exhibits no other signs of distress. See Figure 3.

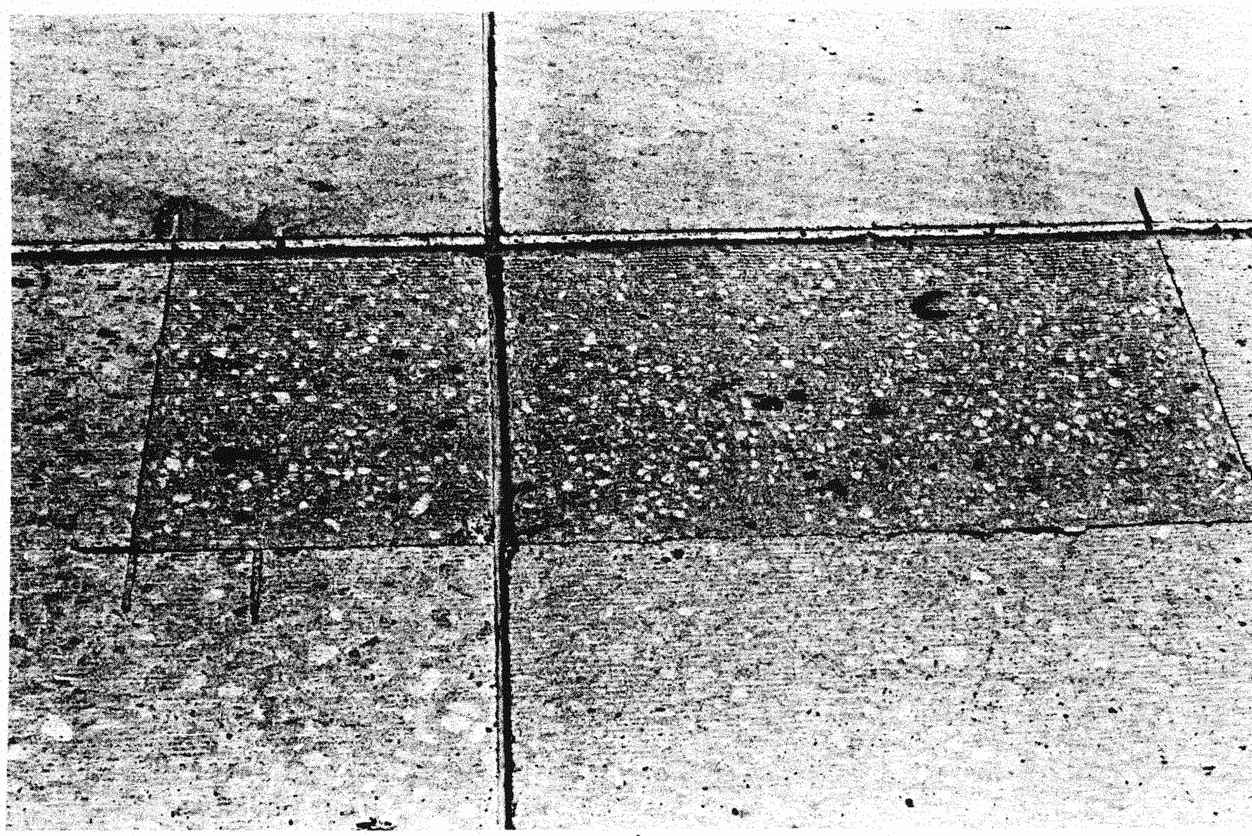

Figure 3. Spall Repair

Slab Stabilization

Slab stabilization was performed on all slabs in the test section, with two exceptions. The newly placed slabs were not stabilized, since the entire slab was removed and the base was properly cleaned leaving no voids. Also, the retrofitting of the dowel bars was in progress causing the stabilization operation to bypass those slabs.

Deflection data was obtained for each joint on a yearly basis. However, the data was inconsistent, and yielded no trends.

Fault data was collected every year since the restoration work was performed. The level of faulting in the test section has steadily increased. See Figure 4. After one year 29 percent of the slabs in the test section had a measurable fault at the joint. After two years, 52 percent of the slabs in the test section had a measurable fault. After three years, 75 percent of the slabs in the test section had a measurable fault.

A core investigation revealed the presence of "cone failure". Cores were taken on three randomly selected slabs. On each slab, one core was obtained directly over an injection hole, and each revealed the conical shattering of the bottom of the slab around the injection hole.

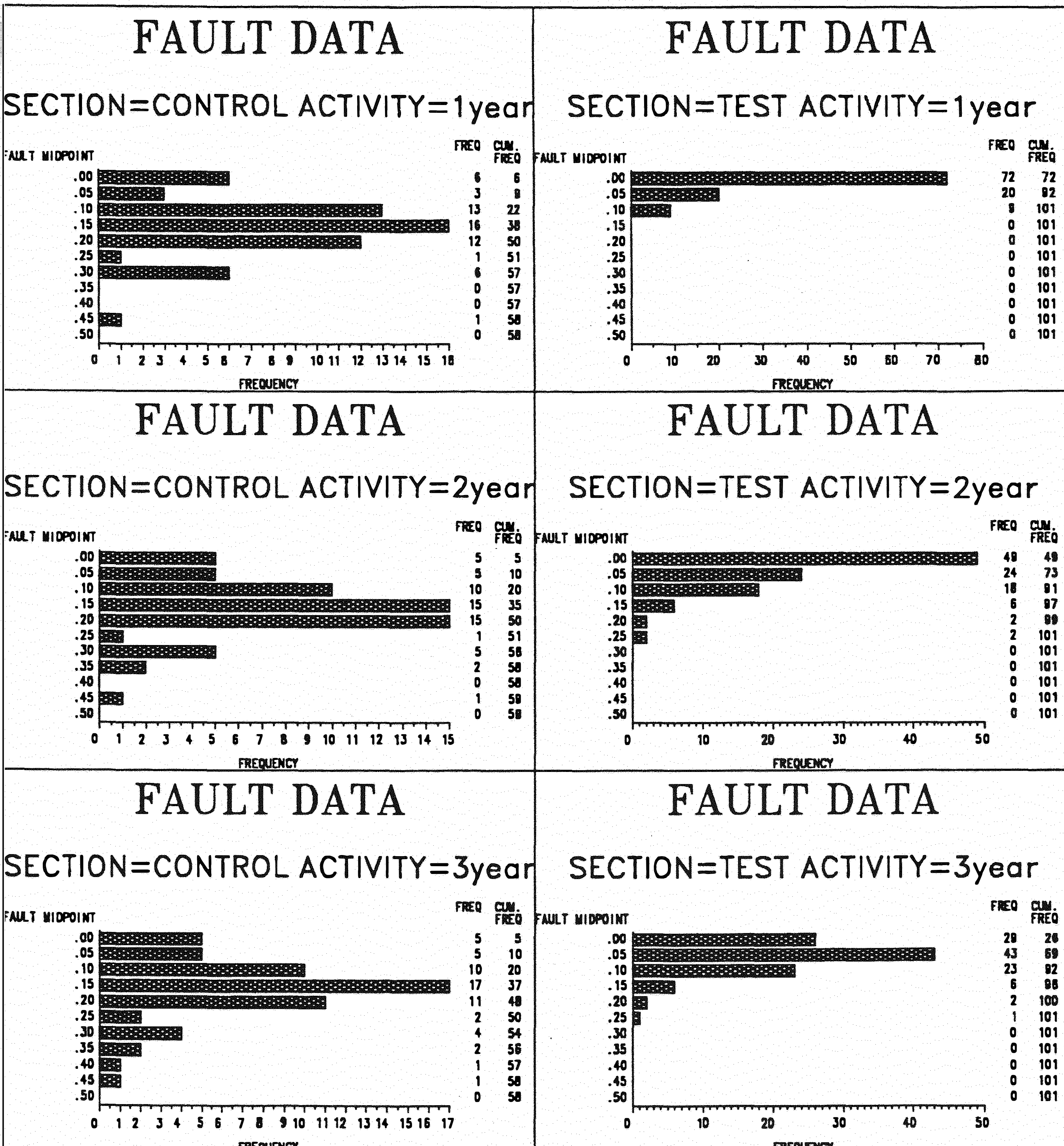

Figure 4. Fault Data

LOAD TRANSFER DEVICES

Two types of load transfer devices, dowel bars and double-v's, were retrofitted on six consecutive joints each for demonstration and evaluation purposes. Three dowel bars were installed in each wheel path of the outside lane, 6 per joint, as shown in Figure 5. Three double-v load transfer devices were installed per joint, on in the inside wheel path and two in the outside wheel path as shown in Figure 6.

Three of the six joints retrofitted with dowel bars had failure of at least one unit. Two of the six joints had failure of two units. The backfill material for these units had cracked, debonded, and in one case totally popped out (Figures 7 & 8). It is important to note that these slabs were not stabilized.

Of the six joints retrofitted with double-v load transfer devices, three joints had some kind of distress with at least one unit. Spalling occurred around three units over two joints, (Figures 9 & 10).

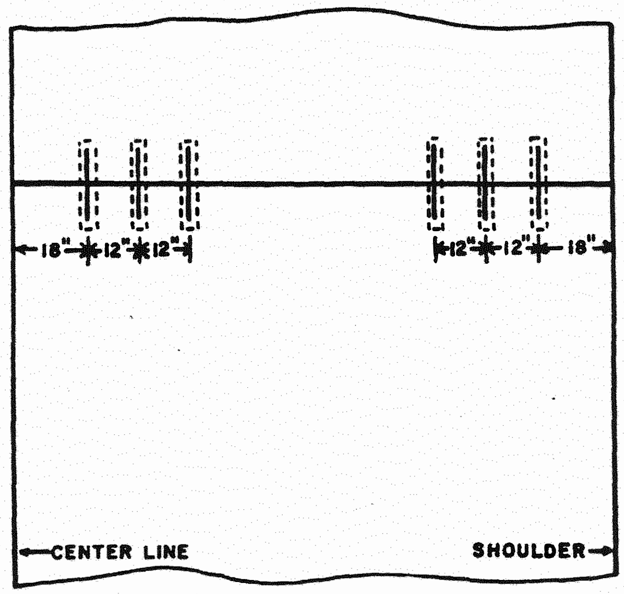

Figure 5. Placement of dowel bars for load transfer.

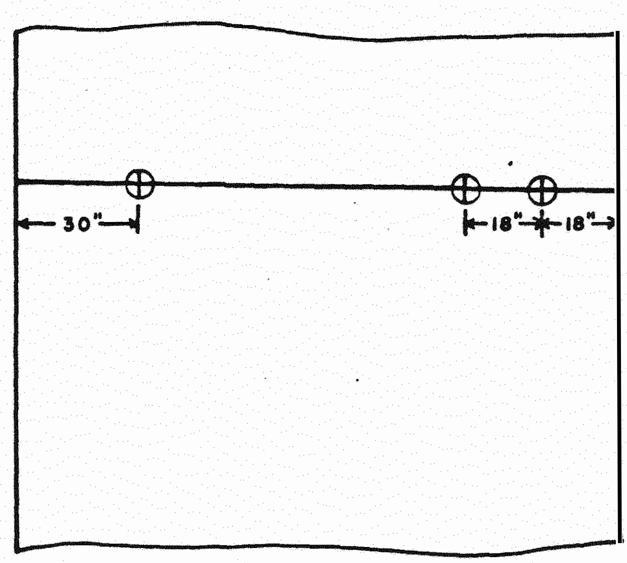

Figure 6. Placement of Double-v devices for load transfer.

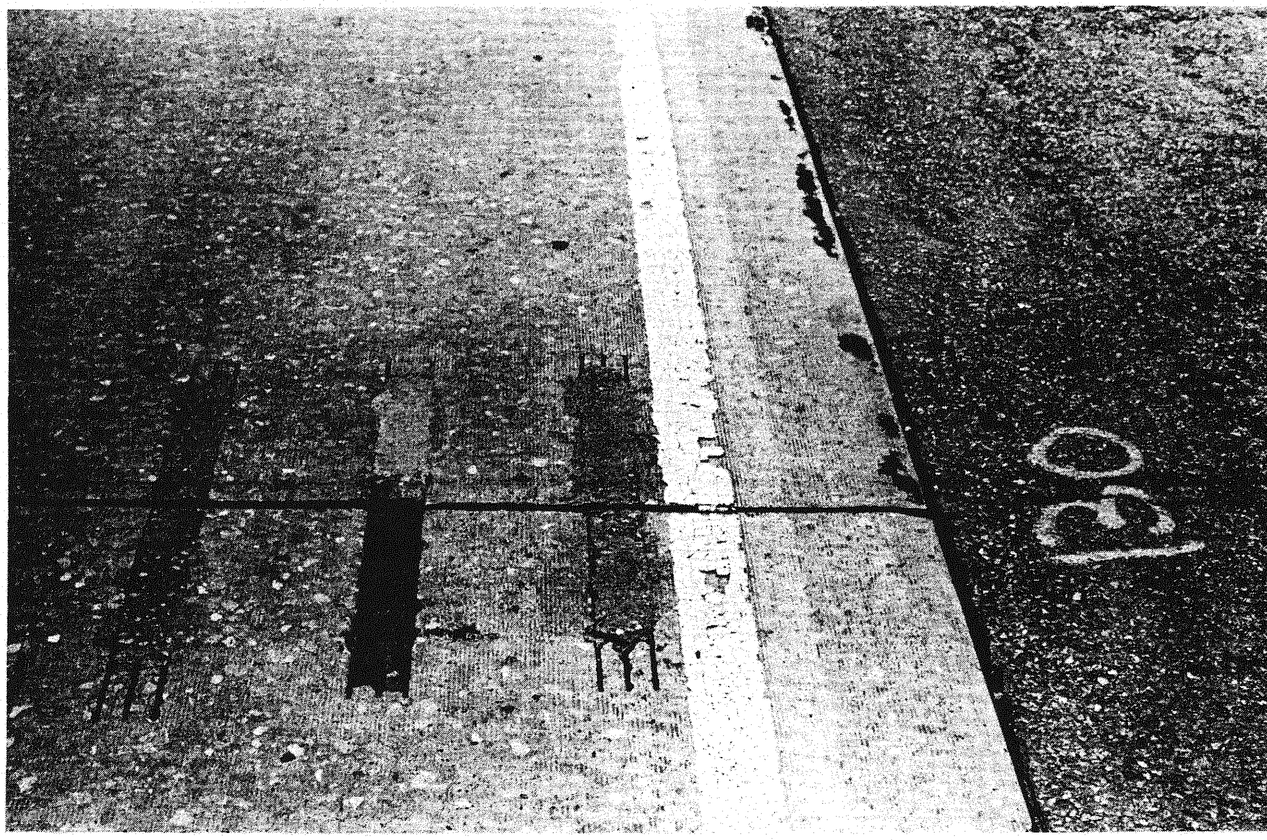

Figure 7. Distressed Dowel Bar

Figure 8. Distressed Dowel Bar

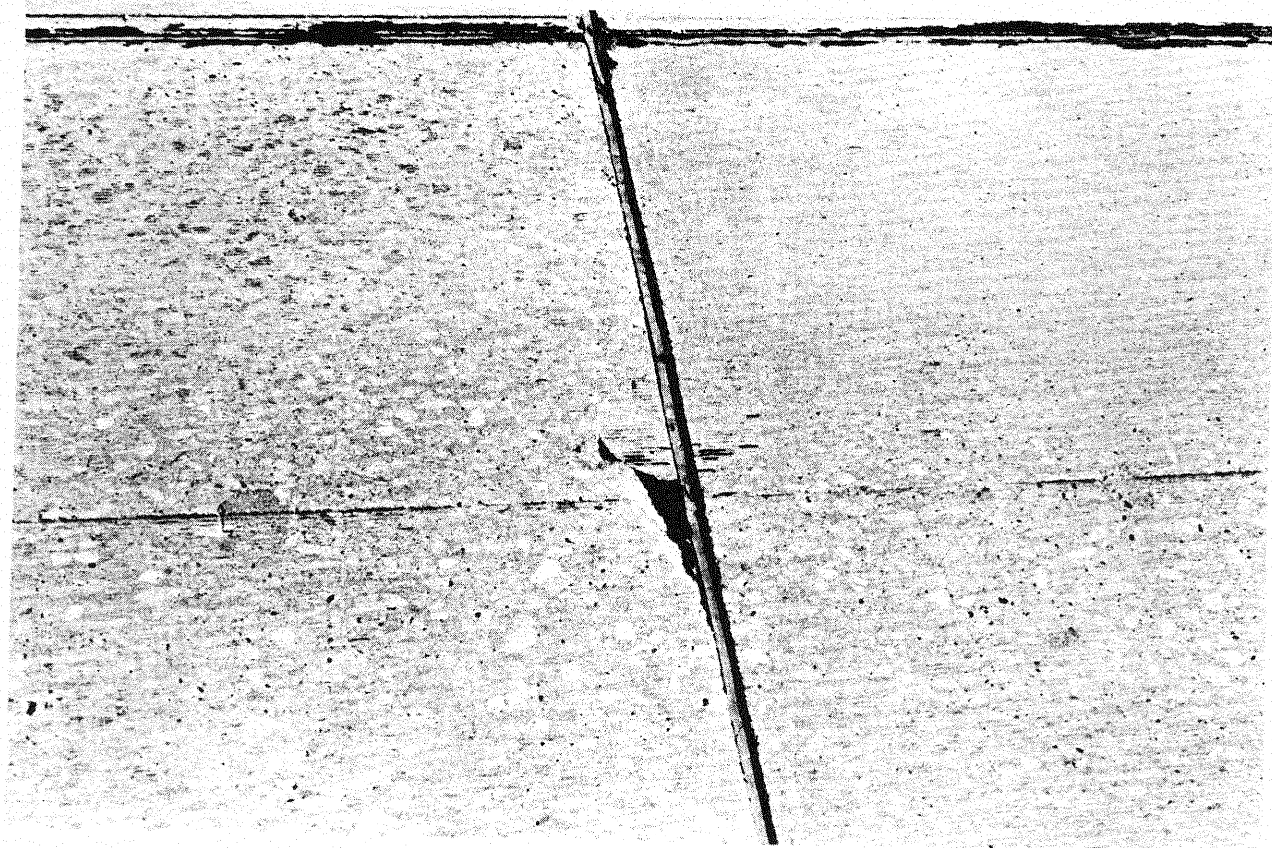

Figure 9. Spall Around Double - V Device

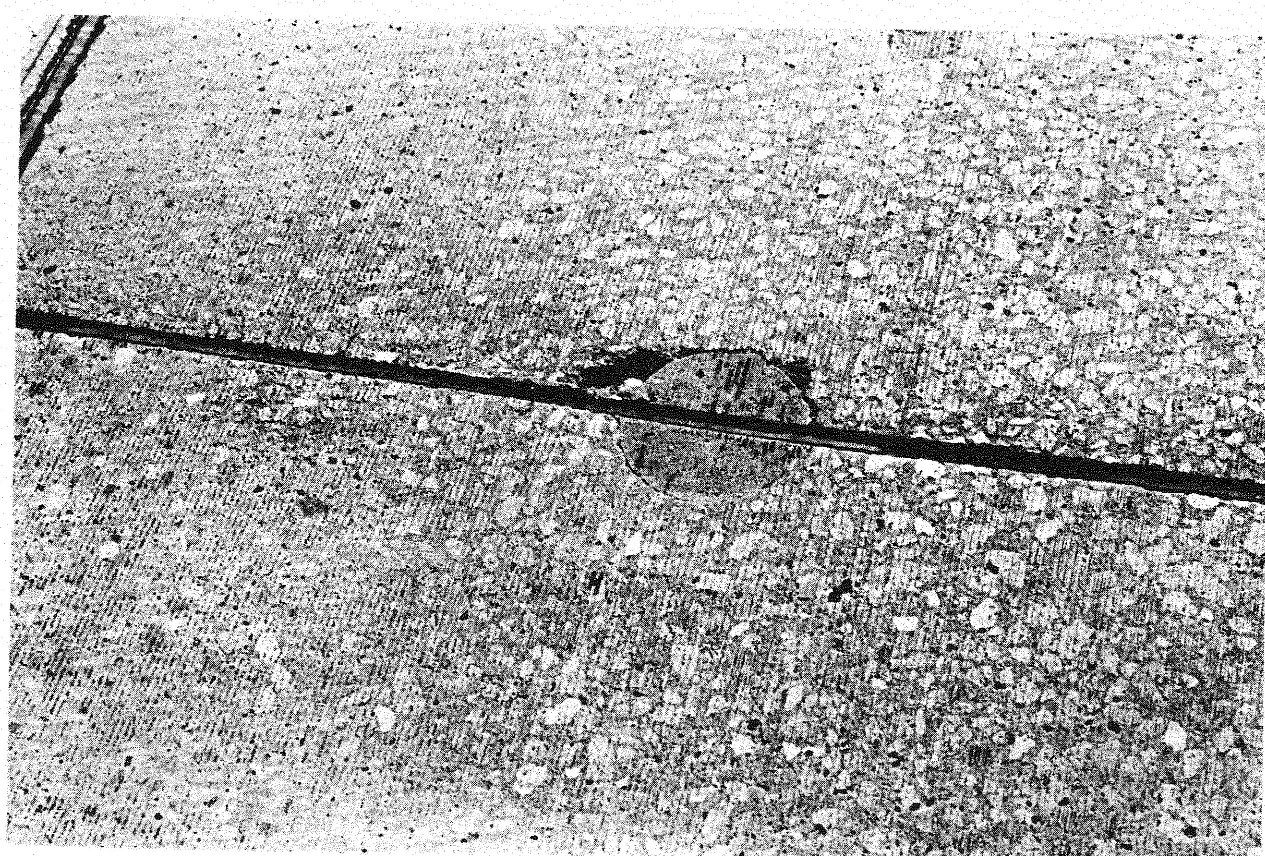

Figure 10. Spall Around Double - V Device

DIAMOND GRINDING

Diamond grinding was performed on the entire test section. Diamond grinding has a two-fold effect in pavement restoration. The first, and most obvious, is that it can grind down faulted joints resulting in a smooth riding surface. The second is that it can also improve the friction characteristics of the pavement.

As shown by the fault data, diamond grinding greatly reduced the average level of faulting. During three years of service, the average level of faulting has steadily increased. However, the annual rate of increase is slowing and the average level of faulting is below 30 percent of the original average fault level.

Diamond grinding initially improved the friction characteristics of the pavement. However, after three years of service, the friction characteristics of the test section have returned to the same level as that of the control section. See Figure 11.

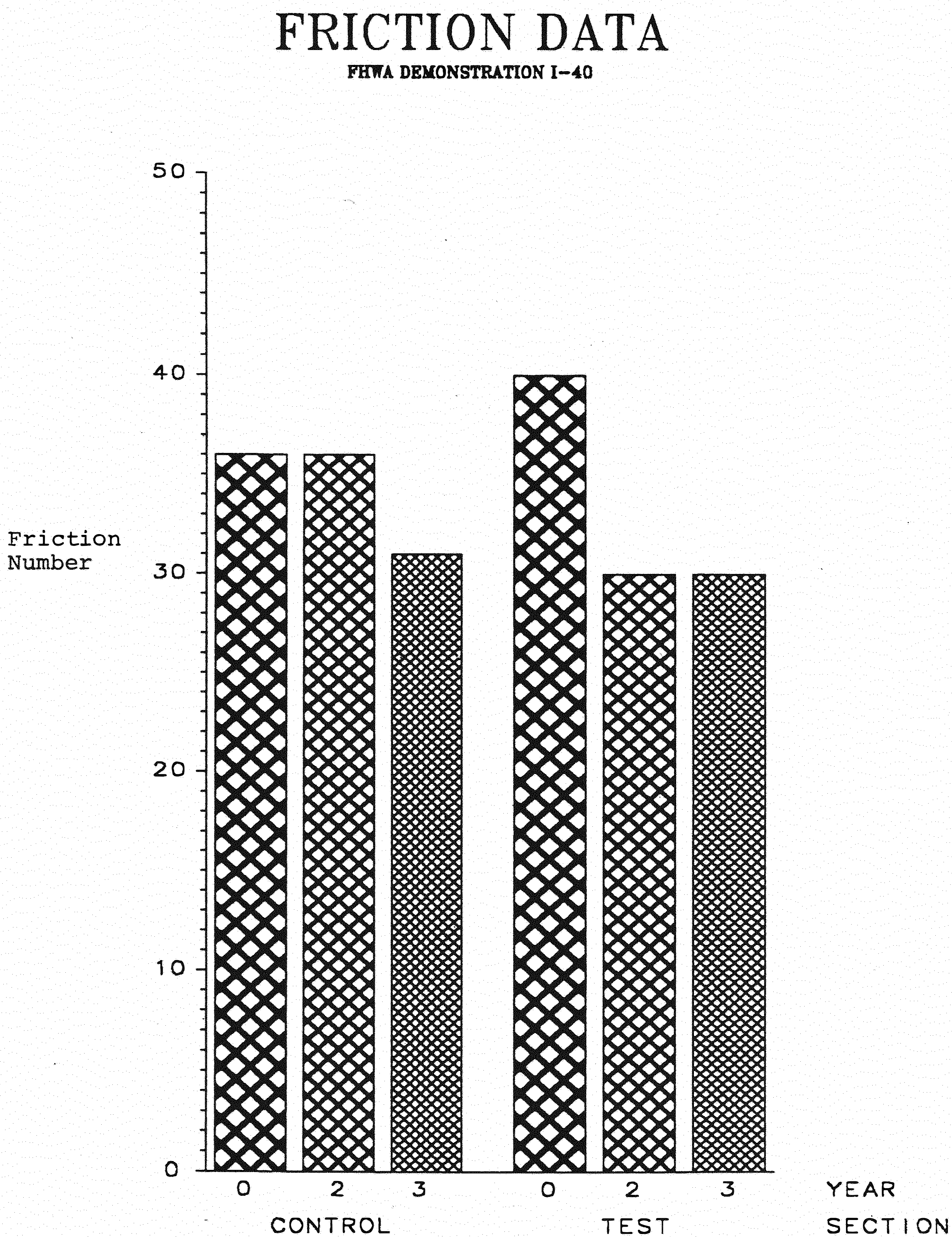

Figure 11. Friction Data

JOINT SEALING

Several types of joint sealant were used in order to evaluate their performance over three years.

The outside longitudinal joint was filled with a petroleum based hot-pour sealant (Crafco - RS221) and the inside longitudinal joint was filled with an asphalt rubber hot-pour sealant (Crafco - AR+). Both applications have performed satisfactorily.

The transverse and centerline joints were filled with four different types of sealant. Most of the joints were filled with silicone sealants, using Dow Corning 888 or General Electric SCS 4403-N. The Dow Corning 888 performed satisfactorily. The General Electric SCS 4403-N had some failures. Although most joints were satisfactory, the SCS 4403-N exhibited cohesion failure in portions of the centerline joint and in one transverse joint. See Figure 12.

The petroleum based hot-pour sealant (Crafco - RS221) was used in a few of the transverse joints. Although the material is performing satisfactorily, incompressibles are collecting in the sealant.

A fourth sealant, nitrile rubber (W.J. Ruscoe - Permanent Sealer) was used in a few of the transverse joints. This material failed early. It bubbled on initial installation, and after three years, portions are missing. See Figure 13.

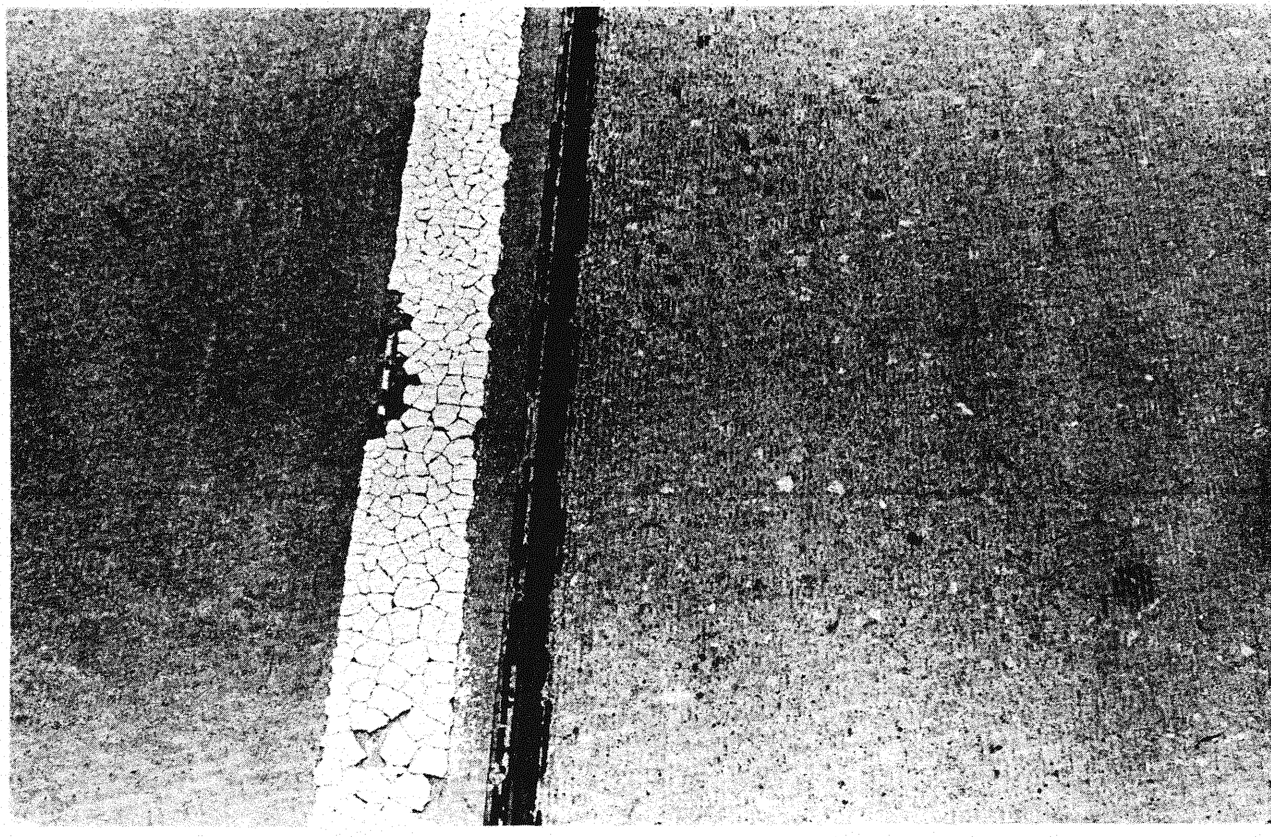

Figure 12. General Electric SCS 4403-N

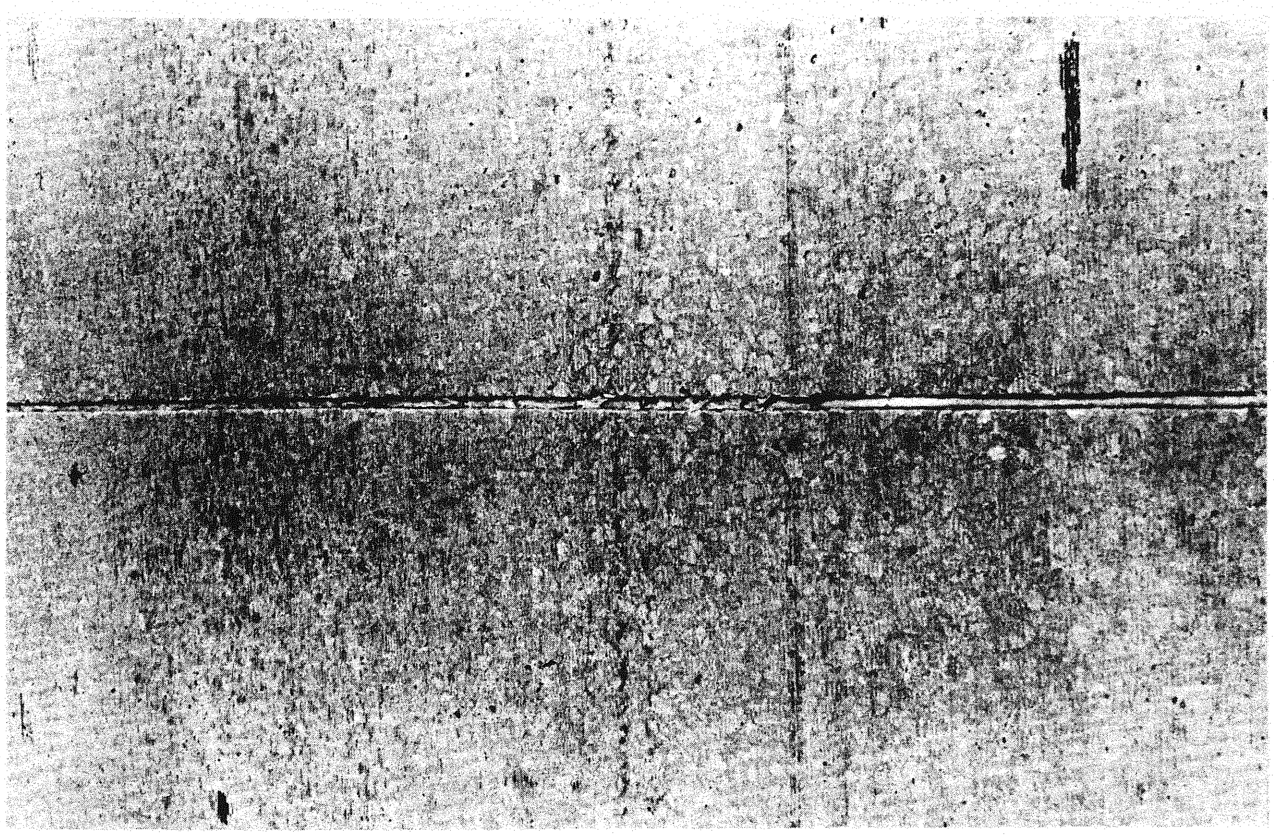

Figure 13. Ruscoe - Permanent Sealer

CONCLUSIONS

1. Replacement slabs that were poured and opened to traffic the same day have provided three years of distress free service.
2. A spall repair using polymer concrete has performed well after three years of service.
3. Refaulting of the joints can occur within three years after restoration.
4. Three out of six joints retrofitted with dowel bars had failure of at least one unit.
5. Three out of six joints retrofitted with double-v load transfer devices had minor distress with at least one unit.
6. Diamond grinding improves friction characteristics initially, but the advantage may be lost after three years of service.
7. Cone failure can occur when rock drilling injection holes with minimal downward pressure.

RECOMMENDATION

It is recommended that a general visual survey of the test section be continued on an annual basis, along with the collection of fault data.