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This report describes attempts by two contractors to used cold planing equipment (CMI Rotomills) to restore riding quality to faulted PCC pavements. It was found that while the equipment could remove substantially all faulting and greatly improved riding quality, there was severe damage to the concrete adjacent to random cracks and transverse joints in spite of considerable effort to prevent it. Because of this damage, the equipment as tested was not considered satisfactory for grinding PCC pavements.

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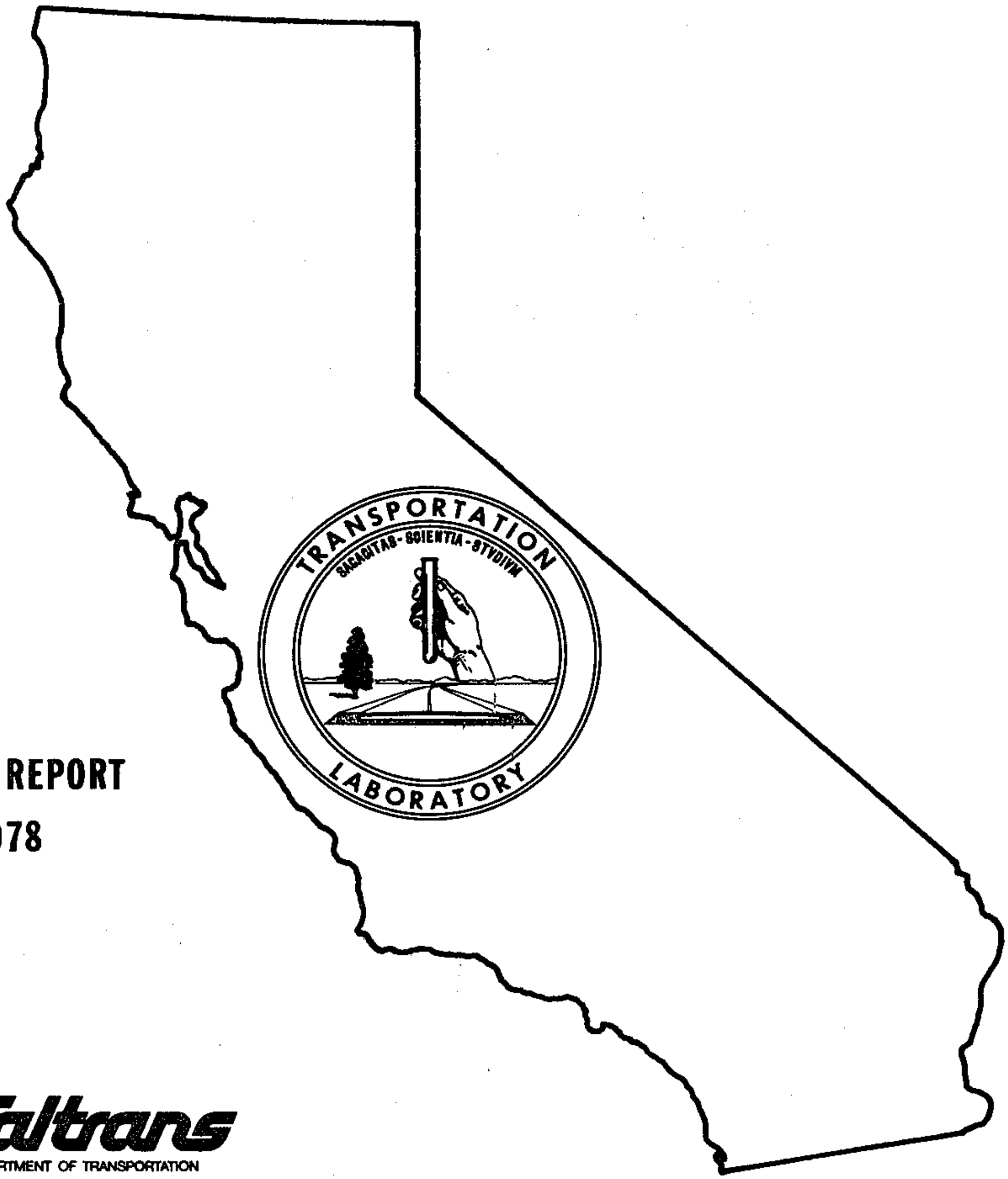
EVALUATION OF COLD PLANERS FOR GRINDING PCC PAVEMENTS



FINAL REPORT

SEPT, 1978

Caltrans

CALIFORNIA DEPARTMENT OF TRANSPORTATION

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STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
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OFFICE OF TRANSPORTATION LABORATORY

September 1978

FHWA No. B-3-7
TL No. 633218

Mr. C. E. Forbes
Chief Engineer

Dear Sir:

I have approved and now submit for your information, this final research project report titled:

EVALUATION OF COLD PLANERS FOR GRINDING PCC PAVEMENTS

Study made by ....Roadbed and Concrete Branch

Under the Supervision of ....D. L. Spellman

Principal Investigator ............J.H. Woodstrom

Co-Investigator ....B. F. Neal

Report Prepared by ....B. F. Neal
and
J. H. Woodstrom

Very truly yours,

Neal Andersen

NEAL ANDERSEN
Chief, Office of Transportation Laboratory

BFN:bjs
Attachment

ACKNOWLEDGEMENTS

The authors wish to express their appreciation for the fine cooperation extended by the Contractors and their representatives, Herb Baze of PR Systems, Inc., and Bryce White of Eisenhour Construction Company; and to the maintenance crews who provided traffic control and other assistance.

TABLE OF CONTENTS

FIGURES

BOND

INTRODUCTION

Many miles of PCC pavements in California are in the need of rehabilitation, because of the deterioration of riding quality. The common defect is step-off or faulting of slabs at transverse weakened plane joints(1, 2,3). When the step-off is about 0.2 inch (5 mm) the effect on ride is noticeable in vehicles with stiff suspension systems. As the step-off increases the ride becomes increasingly objectionable to a large percentage of traffic. In a recent report by the Transportation Laboratory, "Rehabilitation of Faulted Pavements by Grinding"(4), it was concluded that grinding with diamond tipped blades was a satisfactory method of restoring good riding qualities to rough pavements.

New equipment utilizing carbide tipped cutting edges (Cold Planers) is now available and some Contractors with such equipment propose bidding on PCC pavement grinding contracts. Cold planers have been used extensively and quite successfully in removing asphalt concrete and, to some extent, in removing portland cement concrete as well. While the equipment can remove concrete surfaces considerably faster than diamond blades (which could result in cost savings) there was some question as to whether the resultant texture would be desirable, and also whether the finished surface would meet current grinding specifications. To determine the suitability of this equipment, it was decided to set up demonstration projects with various Contractors.

Although four Contractors with Cold Planers were contacted, only two expressed real interest. Accordingly, contracts were negotiated with PR Systems, Inc., of Shelton, Washington, and Eisenhour Construction Company, Inc., of East Lansing, Michigan, and Garden Grove, California. Both Contractors have CMI Rotomill equipment. The contract with PR Systems was for a trial on I-80 near Davis while the one with Eisenhour was for grinding (milling) a portion of SR-101 south of Santa Maria.

CONCLUSIONS

Based on the demonstrations reported herein, a cold planing device with carbide tipped cutting points, as represented by the CMI Rotomill, is not considered to be a satisfactory substitute for diamond blade equipment in the grinding of PCC pavements to restore riding quality.

IMPLEMENTATION

Specifications for grinding PCC pavements to restore riding quality have been revised to require diamond blade equipment.

DEMONSTRATION PROJECTS

To evaluate the equipment, tests were to include:

1. Subjective evaluation.
2. Before and after faulting measurements at joints.
3. Before and after profiles using the California Profilograph.
4. Before and after riding quality based on Road Meter results.
5. Before and after skid resistance.
6. Skid resistance differential between ground and unground lanes.
7. Sound level measurements.
8. Before and after texture profiles.

Davis Trial

The equipment used by PR Systems was a CMI Rotomill PR-375 (see Figure 1) with a cutting head length of 9 ft 2 in. (2.8 m) which was equipped with new cutting points before the test began. The location was on the outside, or number 3 lane, of westbound I-80 at approximately Post Mile 4.0 in Yolo County. The pavement in this area was faulted only about 0.13 inch (3.3 mm) but was considered to be suitable for a fair trial of the equipment (see Figure 2).

Problems were encountered in adjusting cutting depth. This required multiple passes to eliminate ridges. As a result, not as much pavement was milled as was anticipated. Only two sections, each approximately 100 ft (30 m) in length were completed. One was ground in the direction of traffic, and the other against traffic. Forward speed of the machine was also increased on a portion of the

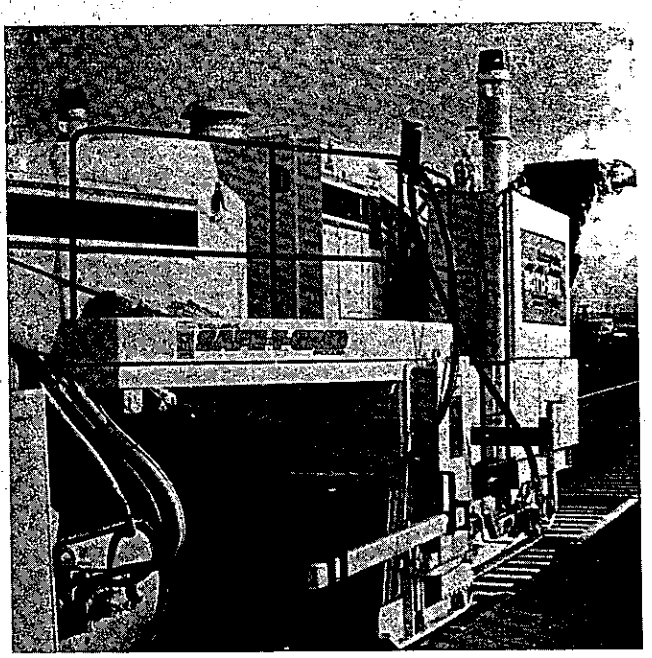

Fig. 1
PR 375 Rotomill

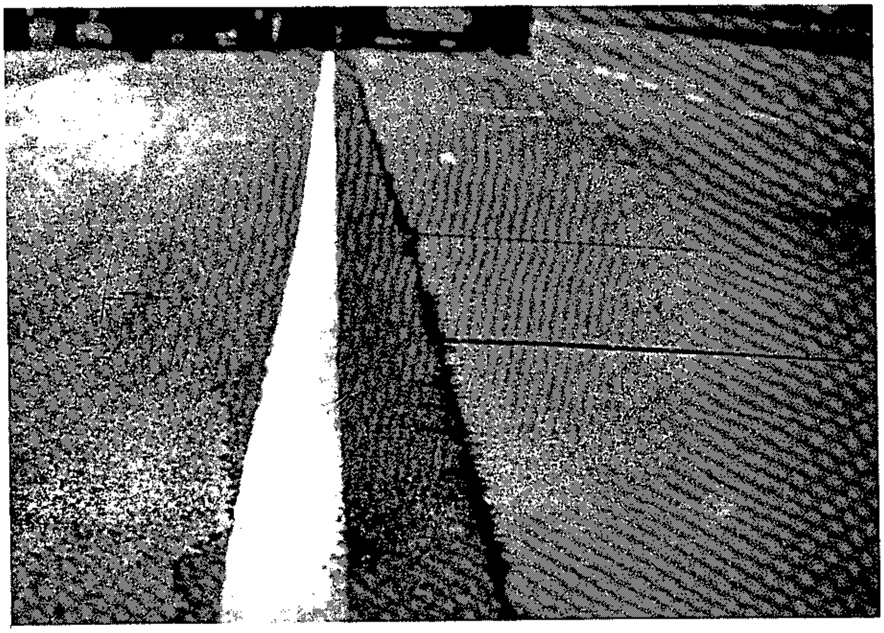

Fig. 2
Typical Pavement Condition

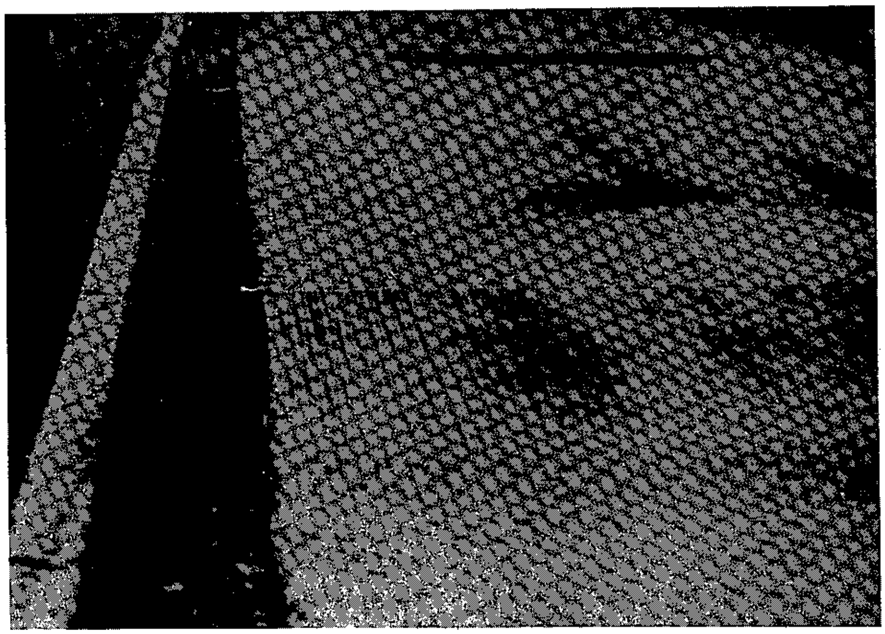

Fig. 3
Pavement Surface After Milling

latter section from 8 ft/min (40 mm/sec) to about 22 ft/min (112 mm/sec). Also in this section, a few of the joints were filled with a "temporary" grout, a proprietary product, "Polycarb", which develops considerable compressive strength rapidly. The purpose of this material was to provide support for the concrete at the joint to prevent spalling and breakage of the edges. The material used to fill the joints is supposed to soften when rewet, and to either wash out of the joint or work out under traffic.

Results

The resultant texture was entirely different from that of diamond ground surfaces or any other texturing method previously observed (see Figure 3). Since the cutting mandrel turns at a constant speed, there was also a noticeable difference in texture when the forward speed of the machine was varied. Once the pavement surface was broomed, the damaged condition of joints became painfully evident (see Figures 4 and 5). Concrete at the edges was broken and removed, resulting in a very unsightly appearance. Joints filled with "Polycarb" seemed to be somewhat less affected (see Figures 6 and 7).

Faulting after milling was difficult to measure because of the roughened texture, but best efforts at measurement indicated a slight residual averaging about 0.06 in. (1.5 mm).

Roughness before milling was measured both with the profilograph and the Road Meter. However, the textured sections were too short for a good evaluation or comparison.

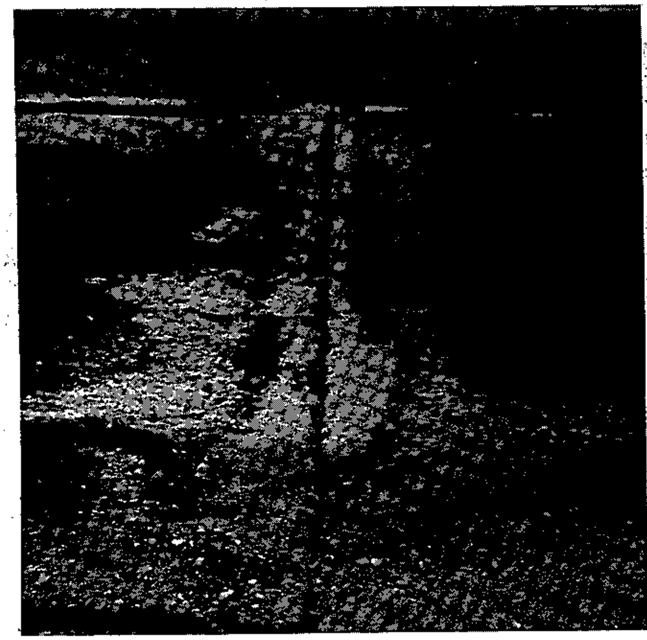

Fig. 4
Joint Condition After Milling

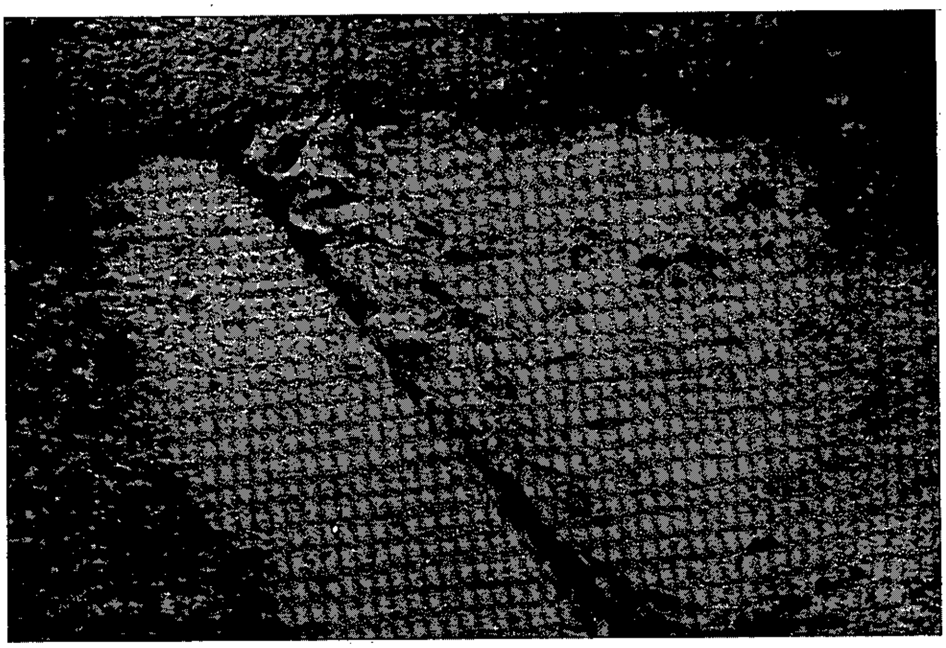

Fig. 5
Joint Condition After Milling

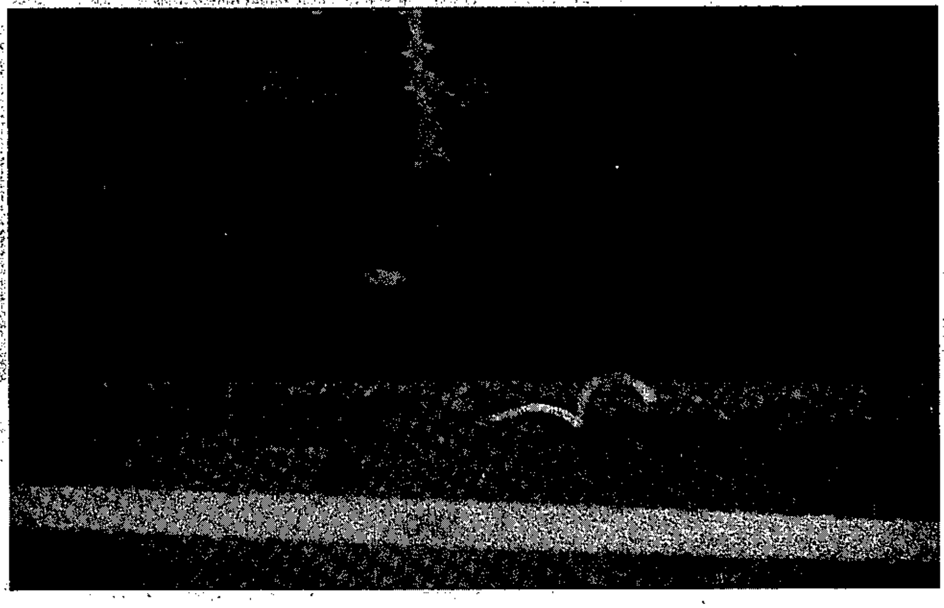

Fig. 6
Joint Filled With "Polycarb"

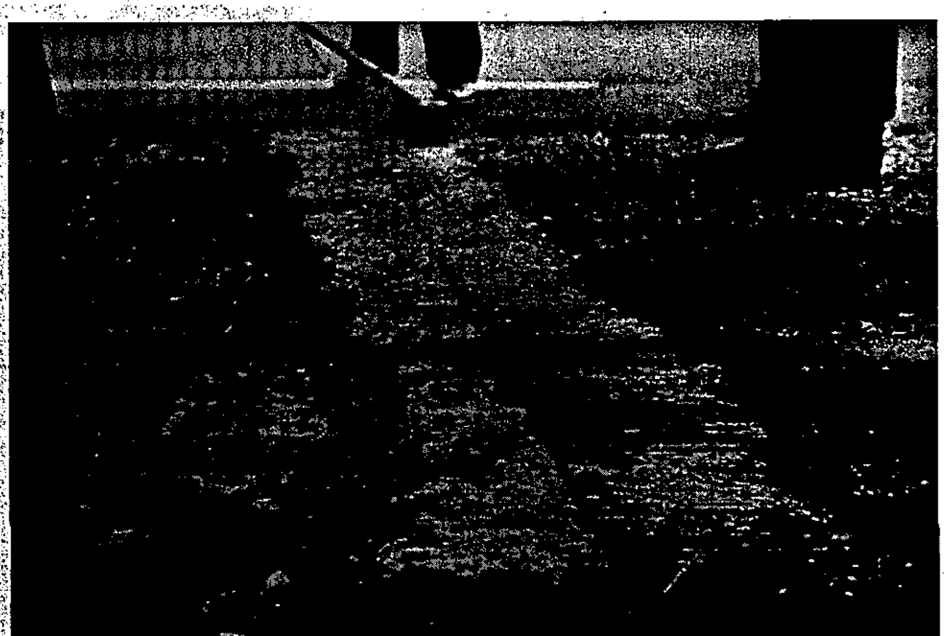

Fig. 7
Filled Joint After Milling

Skid resistance measurements were made with a towed trailer according to Test Method ASTM Designation: E274. Average skid numbers at 40 mph (64 km/hr), SN_{40} were: before milling, 35; after, 42; and in the adjacent unmilled lane, 39, or a differential of 3 points between lanes.

Noise measurements as determined on the A scale were: machine operating from a distance of 50 ft (15 m), 86 dBA; the same vehicles checked on unmilled and milled areas show an increase of noise on the milled area of 1.5 dBA.

Figure 8 shows before and after transverse profiles of the texture made with a laboratory developed texture profilometer.

Santa Maria Trial

The equipment used on this project by Eisenhour was a CMI Rotomill PR-575 (see Figure 9). The cutting head was the same length as the other machine and was also equipped with new cutting points. Two locations were selected on northbound SR-101, one near Post Mile 62, the other near Post Mile 73, both in Santa Barbara County. Transverse joints on both sections were badly faulted (see Figure 10), averaging about 0.25 in. (6 mm) with some joints faulted about 0.4 in. (10 mm).

The two areas were milled on consecutive days, the one at P.M. 62 being done first. All milling was done in the opposite direction from traffic, so that the machine was cutting into the high side of the joints. Two passes were made, the second of which extended a short distance onto the shoulder to prevent a step-off at the pavement edge. No particular problems were encountered, although steel

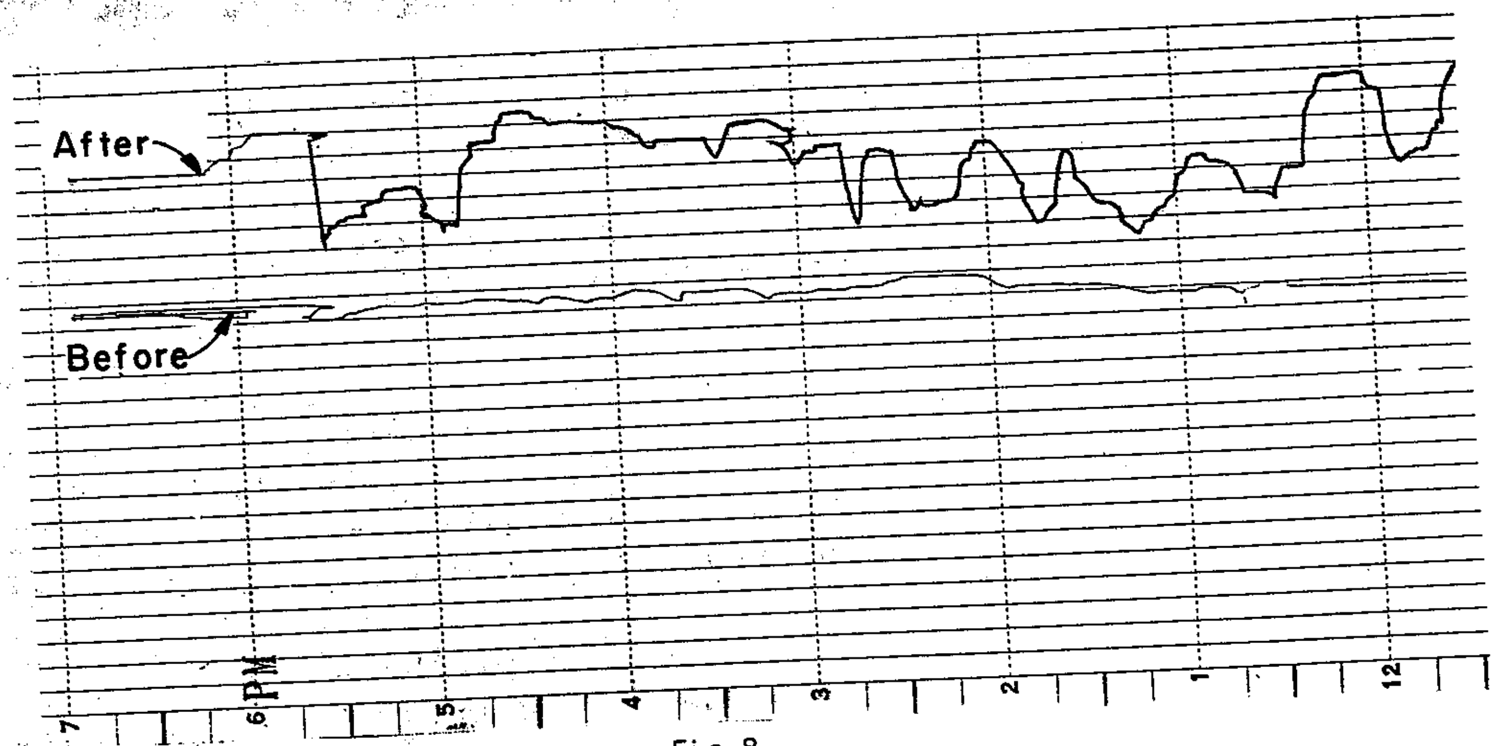

Fig 8

BEFORE AND AFTER TEXTURE PROFILES (TRANSVERSE)
CMI PROJECT
03-YOL-80-4.0

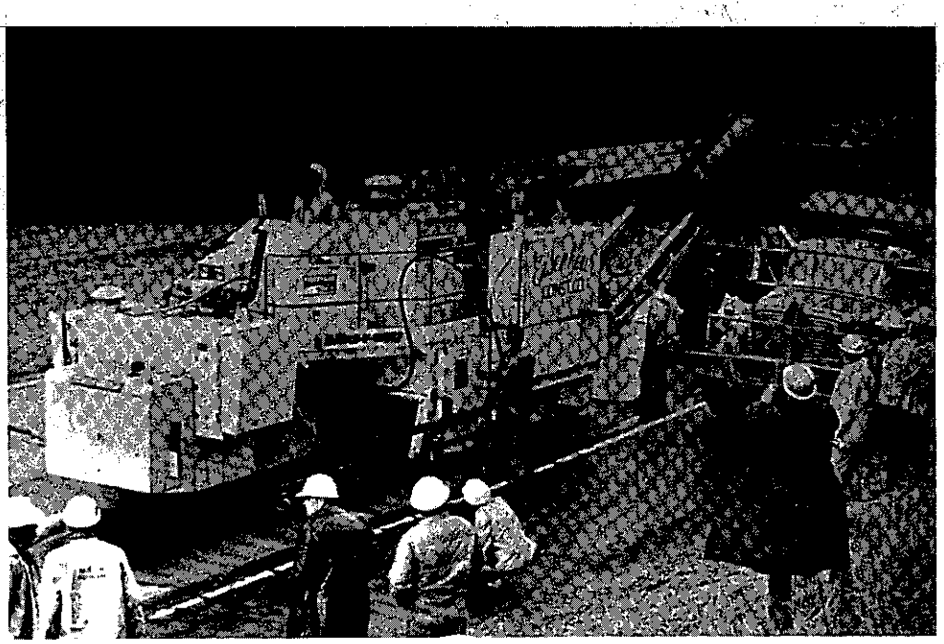

Fig. 9
PR-575 Rotomill

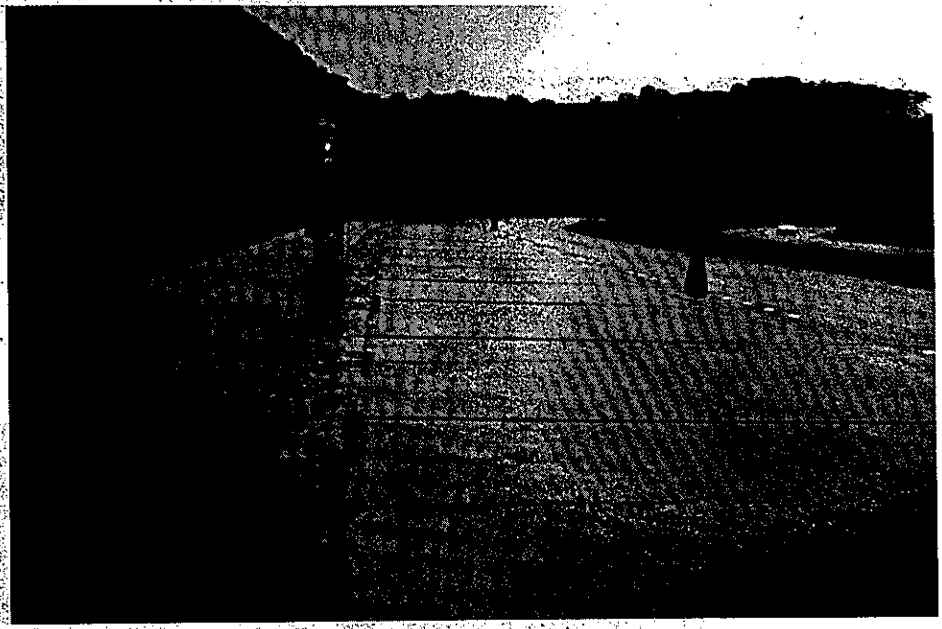

Fig. 10
Typical Pavement Condition

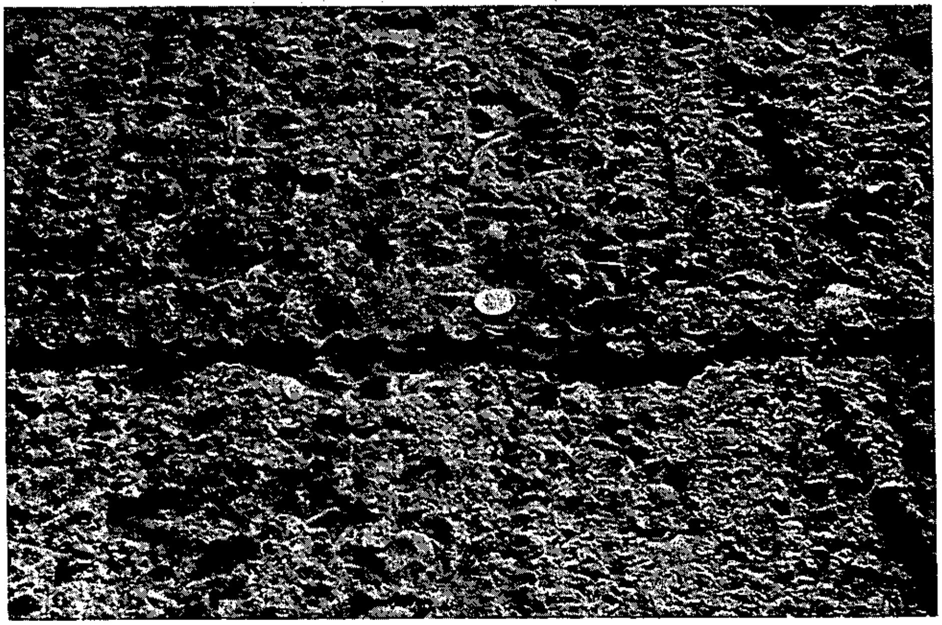

Fig. 11
Steel Joint Insert After Milling

strips placed to form weakened planes at every fourth joint (see Figure 11) did break off a few of the cutting tips. About 1200 lineal ft (366 m) of pavement (approximately full lane width) was milled.

The section at P.M. 73 included areas of badly broken pavement slabs which had been patched with AC. The purpose of this selection was to see if the roughness could be reduced and the slabs left unpatched. The roughness was essentially reduced and after 3 months, it has not been necessary to replace the patches. A distance of about 1600 ft (488 m) was milled.

Some of the joints on each section were "roped" and sealed with the "Polycarb" material. There was difficulty in getting proper depth of the rope and sealant, however, because of gravel or other debris in the joints. Equipment to clean the joints before sealing was not available.

Results

The appearance of the texture was similar to that seen at Davis (see Figure 12). Again, the untreated joints were badly spalled, and the treated joints fared only slightly better. A few of the joints, which were considered to have been sealed satisfactorily, appeared to be only slightly affected.

Faulting was basically removed with only a slight amount remaining. This residual step-off is probably due to the weight of the machine depressing the slab as it approaches the joint. Cutting depth is controlled by averaging skis (see Figure 13) attached to the front and rear of the machine. The amount of concrete removed varied from just a scarifying action to as much as one half inch on the high side of some joints.

Fig. 12
Milled Pavement Texture

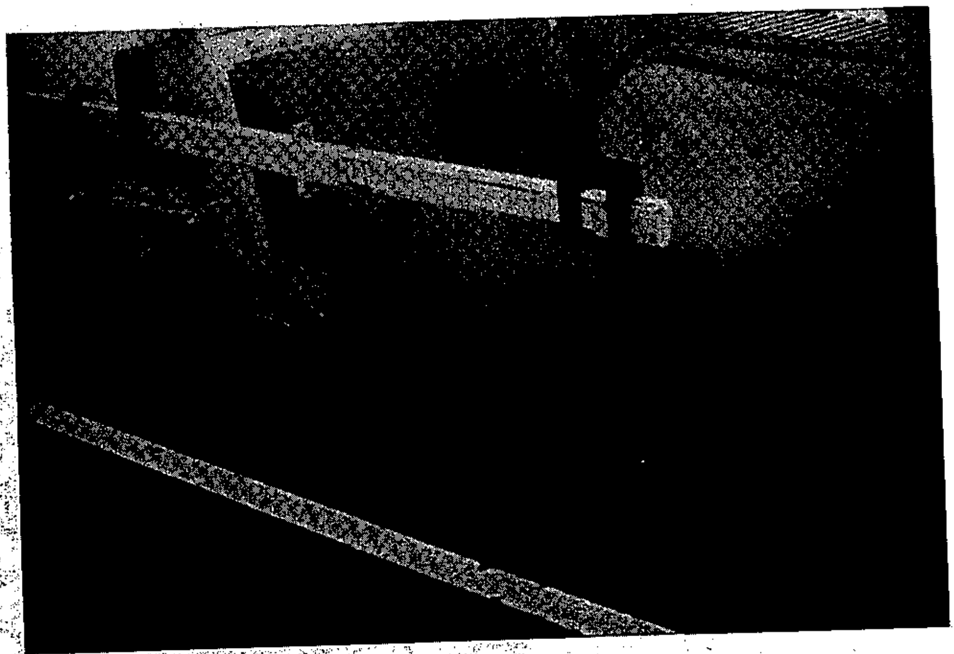

Fig. 13
Rotomill Showing Averaging Ski

Before and after longitudinal profiles were obtained with the California Profilograph at P.M. 62 only. The before profile index was: left wheeltrack, 16 in./mi (252 mm/km); right wheeltrack, 35 in./mi (552 mm/km). The after index was 1 in./mi (16 mm/km) and 4 in./mi (63 mm/km) respectively.

Road Meter results show that at P.M. 62 the PSI before milling was 2.15, and after, 4.20. At P.M. 73 where the pavement was cracked and patched with AC, the before rating was 2.10 but the after figure was only 3.40. However, the riding quality at both locations was significantly improved.

Skid tests were made on continuous pavement (control) in the same lane as milled, in the adjacent No. 1 lane and on the milled portions. Results were as follow:

P.M. 62

	Control No. 2 Lane	Milled	No. 1 Lane
SN_{40}	42	48	43
SN_{50}	39	45	44
SN_{60}	No Test	42	40

P.M. 73

	Control	Milled	No. 1 Lane
SN_{40}	43	50	48
SN_{50}	39	45	45
SN_{60}	38	42	40

To compare the skid resistance of pavements ground with two types of machines, skid measurements were also made on two projects which were ground with diamond blade equipment. One was near the above project at P.M. 73 and was ground about 2 1/2 years prior to these Rotomill tests. The grinding on SR 4 in Contra Costa County was completed about 6 months prior to the skid tests. Following are results:

	Route 101 So. of P.M. 73 (2.5 years)		CC-4 (6 months)	
	Passing Lane Not Ground	Ground Travel Lane	Passing Lane Not Ground	Ground Travel Lane
SN_{40}	43	40	40	43
SN_{50}	39	35	34	38
SN_{60}	38	32	33	38

It appears that milling with the carbide tipped cutters results in greater skid resistance than diamond grinding, although the life of the milled texture is unknown. There was some concern that the milling process might create a dangerous differential skid resistance between lanes, but tests on the resultant texture show no greater differential than existed before either milling or grinding.

Noise measurements at the Santa Maria sites indicated an increase in noise of the milled sections of from 1 to 2 dBA, the same as at Davis. While this increase is measurable, it is not detectable to the ear on the basis of intensity. However, there is a noticeable difference in sound between milled and unmilled sections, evidently a pitch difference.

The transverse texture profiles show results similar to those in Figure 8, taken at Davis.

A total of 9 cores were taken through the milled pavement to check for cracking of the concrete at and below the surface. Cores were from the center of the slab, at random cracks and through joints, both sealed and unsealed. Examination of core slices under the microscope did not indicate any macrocracking.

Santa Maria (Additional)

Following an evaluation of the joint distress on the earlier trials, the Contractor requested, and was granted, an opportunity to try milling an additional section. It was his belief that if the joints were properly prepared and sealed with a strong fast setting material before milling, joint damage would be considerably less. The test was planned for and performed over 2 days. The first day was spent sawing or routing out the joints and filling them. Some 40 joints, a pavement length of about 600 ft (183 m) were treated. Approximately half were filled with "Polycarb", and the remainder with casting plaster. Milling was done in two passes the following day.

Results of the milling were approximately the same as the previous tests. While the filled joints show less damage than those unfilled, it is still considered that damage is too severe. Figures 14 through 21 show prepared joints and one random crack before and after milling. Figure 22 shows a diamond grinding operation, with no damage being incurred at the joint edges.

Fig. 14
Cleaned Joint Being Filled

Fig. 15
Joint Filled With Casting Plaster

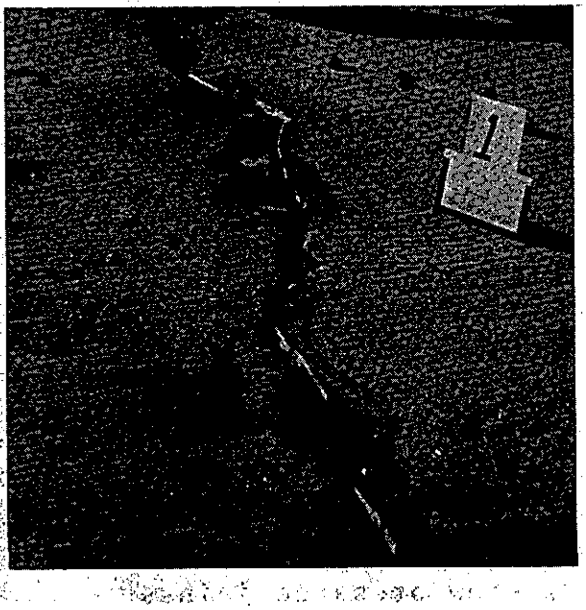

Fig. 16
Routed Random Crack

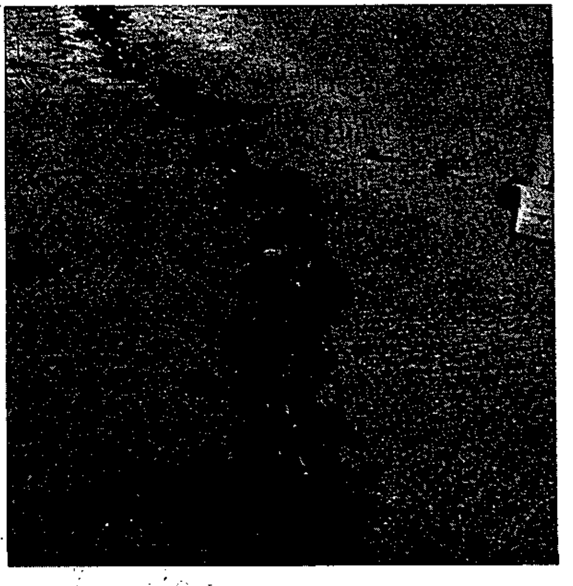

Fig. 17
Filled Random Crack

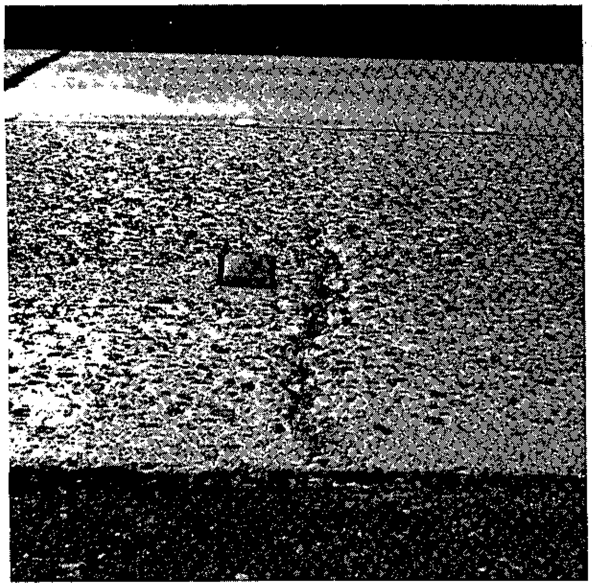

Fig. 18
Random Crack After Milling

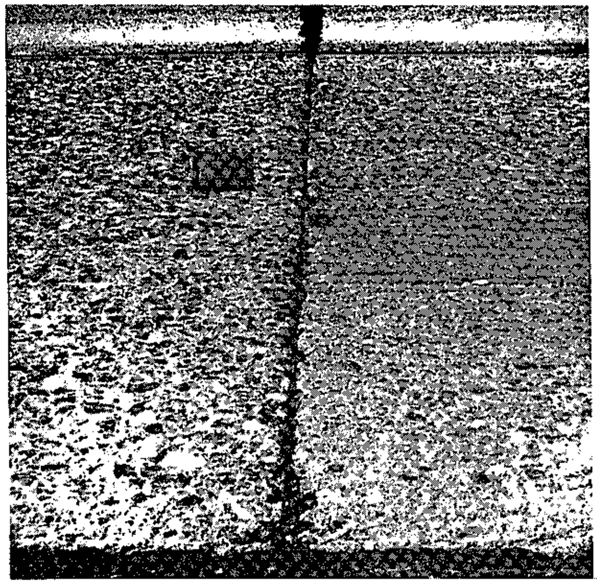

Fig. 19
Filled Joint After Milling

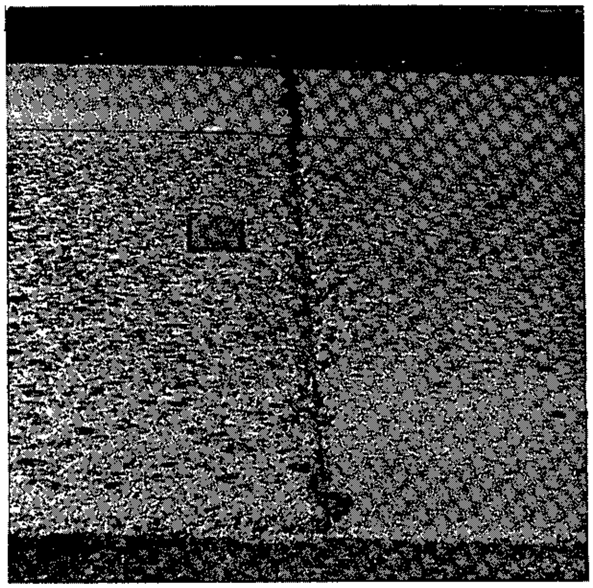

Fig. 20
Filled Joint After Milling

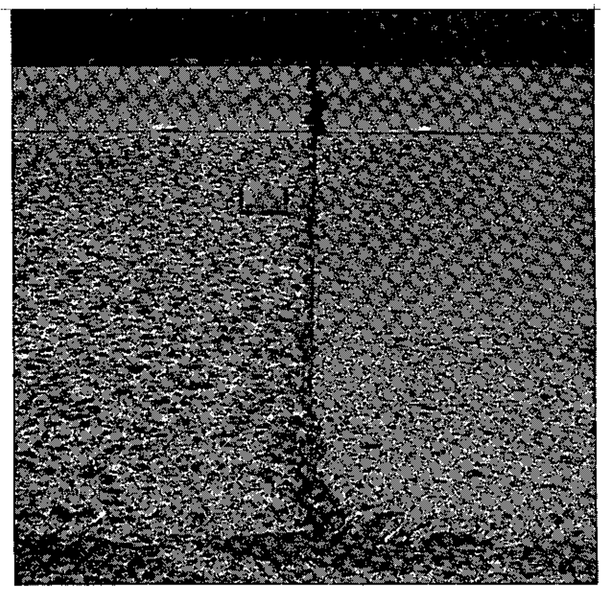

Fig. 21
Filled Joint After Milling

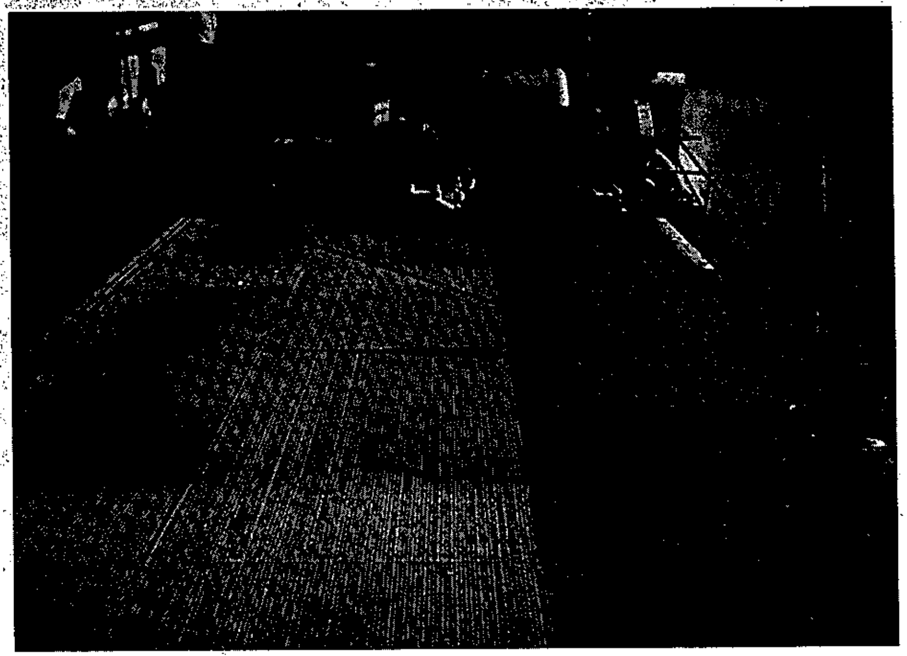

Fig. 22

Diamond Grinding Operation

There was no difference in results between joints filled with "Polycarb" and those filled with casting plaster. On completion of the milling operation, about one half of the filled joints were recleaned and filled with a joint sealant. The remaining were left filled to check on self-removal of the filler material.

Cleaning and temporary filling of joints greatly increases the cost of this type of grinding operation. Although an economic analysis was not made, it would appear that most, if not all, of the expected savings from the use of cold planers would be lost, if such preliminary work had to be performed.

Summary

It is believed that the demonstration projects provided a fair trial of the CMI Rotomill equipment. Every effort was made to provide each Contractor with the fullest cooperation possible. In spite of their best efforts, however, they were unable to restore a pavement to a condition suitable to the State. Basically, this was because of the joint degradation caused by the milling operation. The small residual fault left at some of the joints was not considered a real problem, since it could probably have been removed by another pass of the machine.

Unless an agency is willing to accept badly spalled joints, as shown in the pictures in this report, the cold planer, as represented by the CMI Rotomill, is not considered a satisfactory substitute for diamond blade grinding.

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