INSPECTION OF PAVEMENT PROBLEMS ON I-275 AND ON I-75 FROM THE OHIO LINE NORTHERLY TO THE HURON RIVER

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CONSTRUCTION AND TECHNOLOGY DIVISION

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16. Abstract

This project monitored the reconstruction of portions of I-275 and I-75 in Southeast Michigan. The purpose of this study was to verify the conclusions reached in previous reports regarding poor drainage, filter problems with the Open Graded Drainage Course (OGDC), and the placement of the Continuously Reinforced Concrete (CRC) reinforcement and longitudinal cracking. On I-275 there were two projects in this study. Project 1 was rubblized and Project 2 was reconstructed. On I-75 the driving lane was replaced, concrete pavement repair was done on selected sites in the center lane, and a dowel bar retrofit was done on the center and median lanes.

I-275-The conclusions reached in the previous reports on I-275 regarding the causes for the longitudinal cracking are still valid. Questions have been raised regarding the quality of the construction of the original CRC pavement. This study concluded that the bar spacing and alignment were good, but that the depth of the bars varied greatly across the width of the pavement. There appears to have been a good bond between the concrete and the reinforcement, and the longitudinal cracking in the CRC pavement followed the longitudinal reinforcement bars. For the portion of I-275 that was rubblized, the rubblizing was not uniform. For the portion of I-275 that was reconstructed, further investigative research should be done to determine the long term performance of the OGDC on the three different types of bases that now exist after reconstruction.

I-75-Due to the disruptive process used for pavement removal, deterioration of the base over time could not be quantified. This study was able to conclude that the amount of distress (cracking and/or faulting) in the travel lane is directly proportional to the amount of mixing of the sand subbase and the OGDC and that the probability for material to migrate toward the retrofit underdrain would increase with the amount of distress present in the travel lane. However, because of the way the concrete was removed, only a general verification of the previous conclusions could be made.

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INTRODUCTION

The purpose of this study was to verify the conclusions reached in previous reports (1, 2, 3, 4, 5, 6) regarding poor drainage and filter problems on both I-275 and I-75 and with the Open-Graded Drainage Course (OGDC) on I-75. Also, to verify the conclusion reached in the placement of the continuously reinforced concrete (CRC) reinforcement and longitudinal cracking on I-275 (1, 2, 3, 4, 5).

The I-275 freeway begins at I-75 in the south and extends north to I-696 a distance of approximately 39 miles. The pavement, which is 9-inch thick CRC, was opened to traffic in segments, beginning in 1975 with the final segment opened in 1977. The general location and alignment of the freeway are shown in Figure 1. For simplicity, each original construction project has been assigned a code number that will be used throughout this report whenever reference is made to a specific project. Code numbers ranging from 1 thru 13 have been assigned consecutively from south to north.

The I-75 freeway begins at the Ohio State Line and extends north to the Michigan/Canada border at Sault Ste. Marie, Michigan, a distance of approximately 361 miles. The section involved in this study is 24.9 miles long and runs from the Ohio State Line north to the Huron River (Monroe/Wayne County Line). The roadway, which is a conventional jointed concrete pavement, was originally 24-ft wide, 10-in thick concrete constructed in segments between 1955 and 1957 and was widened to 36-ft between 1973 and 1977. This area was reconstructed as a 36-foot wide, 11-inch concrete pavement [using recycled concrete (for the first 12 miles NB and SB) and non-recycled concrete (northerly 12.9 miles northbound and southbound)] and an OGDC. The reconstruction was started in 1984 and was completed in 1990. The projects for the widening for 1973 thru 1977 are shown in Figure #2 and the projects for the reconstruction for 1984 thru 1990 are shown in Figure #3. For simplicity, each project in Figure #3 has been assigned a code number that will be used throughout this report whenever reference is made to a specific project. Code numbers ranging from I through V have been assigned consecutively from south to north.

On I-275 projects 1, 3, 4, 5, 6 were involved in this study. Project 1 from I-75 to US-24 was rubblized while the northbound lanes of the northern 0.91 miles of Project 3, all of Projects 4 and 5 and the southern 2.2 miles of Project 6 were completely removed and replaced during the summer of 1997. The southbound lanes on I-275 in Projects 1, 2, 3, 4, 5, and 6 were removed and replaced during the summer of 1998 but were not included in this report. On I-75 all of projects I, II, III and the southern 0.3 miles of southbound on project IV were involved. The northbound driving lane was replaced, concrete pavement repair was done on selected sites in the center lane, and a dowel bar retrofit was done on the center and median lanes. The southbound driving lane, Projects III and IV, was also removed and replaced in the summer of 1997 but was not included in this report.

PROJECT FINDINGS

I-275

Pavement surveys, conducted in 1977, indicated some longitudinal cracking and punch-out failures on three of the projects. The cause of this early distress was immediately investigated and resulted in three reports (1, 2, 3). In brief, these reports indicate that differential frost action in the base was the most probable cause of the longitudinal cracking, and that volume change, or expansion of the subbase upon freezing, was responsible for development of abnormally high stresses in the CRC during the thaw cycle, at which time the consolidating subbase changes to a fluid providing an elastic pavement support condition.

In 1979, a study was conducted to confirm the differential frost action indicated in the previously mentioned reports (1, 2, 3). This report (4) confirmed the previous conclusions and recommended that:

1. Plowed-in trenchless underdrains should be installed in section 3. Frost heave measurements should be made on sections 6, 7, 9, 10, 11, 12, 13 and if frost heave exceeds one inch, such as occurs in section 3, these sections should also benefit from retrofit plowed-in underdrains.

2. All sources of surface infiltrating water have the potential to cause differential frost heave. Therefore, it is important that all joints and, in particular longitudinal cracks, be sealed.

3. Dense-graded aggregates should not be used for pavement base layers.

4. Sand or Class II materials should not be used for the subbase layer over clayey or other relatively impervious subgrades unless the layer can be made thick enough, the drainage path made short enough, and the sand permeable enough to allow one-half of the gravity drainable water to drain in 10 days or less.

In 1980, Project Nos. 4, 5 and the northbound portion of Project No. 8 were retrofitted with edgedrains. A 1983 memorandum report (5) from L.T. Oehler to K.A. Allemeier showed that the longitudinal cracking did not increase as much in these sections as compared to the sections without retrofitted edgedrains.

The conclusions reached in the previous reports on I-275 regarding the causes for the longitudinal cracking are still valid. Since the studies were done in the late 1970's and early 1980's, questions have been raised regarding the relative location (depth, bar spacing, alignment) of CRC reinforcement bars, and whether or not the longitudinal cracking in the CRC pavement follows the bars. Also, it was questioned whether the concrete was well bonded to the longitudinal bars. Figure #4 shows that the bar spacing and alignment are good. However, the depth of the bars varies greatly across the width of the pavement as shown in Figure #5. Figure #6 shows that there appears to have been a good bond between the concrete and the reinforcement. The longitudinal cracking in the

CRC pavement followed the longitudinal reinforcement bars (either directly on top of the bars or directly along side of the bars) as shown in Figure #7.

Project No. 1

The rubblizer used on this project was a multiple headed guillotine breaker. The rubblizing was not uniform. There were areas where the concrete rubblized easily down to or below the CRC reinforcement, and there were areas where the concrete hardly rubblized at all, as can be seen in Figure #8. However, the problems with the rubblization did not appear to have been caused by the longitudinal CRC reinforcement. There appeared to be no difference in the rubblization of the good concrete and the areas where there were delaminations or punch-outs. The longitudinal CRC reinforcement bars bowed up out of the rubblized concrete. It appeared to be from relieving the tension that the longitudinal reinforcement bars were under, due to thermal forces in the concrete slab. A similar condition occurred on projects 3, 4, 5, 6 and is shown in Figure #10.

A 22A limestone from Pit # 58-1 (France Stone) was used as the crushed stone on this project for the subbase and base. Figure #9 shows that the limestone appears to have a large fine content (specifications allowed a maximum of 10% loss by wash). By observation, the base and subbase did not appear to drain very well. Also, as can be seen in Figure #9, there appears to be some pumping of the subgrade into the crushed stone.

Project Nos. 3, 4, 5, 6

A guillotine breaker was used to break up the concrete prior to removal and there was no vibrating of the reinforcement out of the concrete. Figure #10 shows that the reinforcement bowed up out of the concrete due to relieving the tension in the longitudinal reinforcement bars. The bowing took place when the bond was not completely broken between the reinforcement and the concrete during the breaking process, and the reinforcement met resistance within the concrete after it had been broken.

During the original construction of I-275, steel furnace slag was used as an aggregate base for concrete on projects 3, 4, 5. The reconstruction provided the opportunity to inspect the slag aggregate prior to its removal and the placement of a dense-graded aggregate separator and an open-graded drainage course. The 4-inch slag aggregate base had turned into a material similar to a weak concrete and the sand subbase turned into a material similar to a weak sandstone varying in depth from 1/4 to 6 inches. This condition occurred due to the unhydrated lime component of the slag aggregate leaching out and forming a calcium carbonate deposit as shown in Figure # 11. The depth of the sand subbase that turned into a weak sandstone depended on the amount of moisture present. The more moisture the deeper the sand subbase became like a weak sandstone.

The slag aggregate base was to be completely removed from north of the bridge over the Conrail Railroad (Sta. 536+00) to south of Pennsylvania Road (Sta. 861+24). However, it was not.

The slag aggregate was partly removed from Sta. 536+00 to approximately 150 feet south of Willow Road (Sta. 646+36) and completely removed from Sta. 646+36 to approximately 2600 feet south of Pennsylvania Road (Sta. 861+24). From Sta. 861+24 to north of the CXS Railroad (Sta. 1015+89.67) the aggregate base was natural gravel (22A) and was left in place. The three cross-sections that are now in place will provide an opportunity for future comparative performance study of a dense-graded aggregate separator and an open-graded drainage course that has been placed on 1) steel furnace slag aggregate, 2) sand subbase, and 3) natural gravel (22A).

The retrofit edgedrains placed on Projects 4 and 5 in 1980 were removed during this reconstruction providing an opportunity to check their condition after 17 years of service to determine how well they had been functioning. The geotextile cover sock was extremely dirty and partly blinded off and the inside of the pipe was approximately 1/8 to1/4 full of silt and leachate. Leachate also formed in the grooves on the inside and outside of the pipe. In 1991, a NCHRP study was conducted on the *Long Term Performance of Geosynthetics in Drainage Applications*. A site on S.B. I-275 (in project #5) south of North Huron River Dr. (Sta. 780+00) was chosen for inclusion in that study. As shown in Figure #12, the amount of silt and leachate inside and outside the pipe has increased in the six years since the NCHRP study.

I-75

In 1980, a study was conducted to determine the cause(s) of performance problems (cracking and faulting of the slabs) in the roadway constructed between 1955 and 1957 and widened between 1973 and 1974. *These problems were confined to the outside (traffic) lane which was added to the 25-year-old two lane pavement.* The report (6) was divided into two parts. Part 1 dealt with the pavement performance and Part 2 dealt with the pavement foundation. Part 1 concluded that:

1. The concrete compressive strength is well above the design strength; thus, it does not appear to be a factor in the cause of the transverse cracking problem.

2. Approximately 60 percent of the cracks in the added lane were continuations of existing cracks in the old lane. The remaining cracks are thought to be caused by hookbolt restraint and heavy load application.

3. Core and faulting data indicate that there are currently about 700 cracks on the subject pavement with fractured or yielded steel reinforcement.

4. Based on the average number of transverse cracks per slab and the number of faulted cracks per slab, the northbound roadway exhibits more distress than the southbound roadway. The poorest performing section was on the northbound roadway located from milepost 8 to milepost 13.

The amount of faulting and the amount of fractured steel indicate base support problems, which were addressed in Part 2 of the report.

Part 2 concluded that two primary pavement deficiencies are causing premature pavement failures: 1) the subbase is subject to volume change on freezing thereby losing support capacity when thawing; and 2) the limestone aggregate base used for the add-on lane only, in localized areas, is subject to rapid degradation causing the base to be subject to highly detrimental frost and pumping action. Also, the report recommended that a *plowed-in* retrofit subbase underdrain be installed to improve foundation drainage conditions.

The conclusions reached in Part 1 of the 1980 study could not be confirmed as the concrete pavement was completely removed and recycled during reconstruction between 1984 and 1990. The conclusions reached in Part 2 of the 1980 study regarding the problems with the subbase are still valid. However, the conclusions made regarding the dense-graded aggregate base are not valid, as the base was removed during reconstruction.

<u>Projects I and II (Northbound I-75)</u>

Due to the process that was used to remove the pavement (Figure #13) and grade the OGDC base for the pavement inlay project on northbound I-75, no conclusive comparison could be made with the condition of the base for the inlay project with the condition of the base at the time of pavement removal for the pavement patching projects let by the Maintenance Division, which were done in 1995 and 1996. The pavement patches ranged in size from 12-foot x 12-foot to 36-foot x 12-foot.

From observations made during the pavement patching projects, it was concluded that the amount of distress (cracking and/or faulting) in the travel lane might be directly proportional to the amount of mixing of the sand subbase and the OGDC (Figure #14). Also, it was concluded that the probability for material to migrate toward the retrofit underdrain would increase with the amount of distress present in the travel lane. However, because of the way the concrete was removed and the OGDC was graded (Figure #13) only a general verification of these conclusions could be made. Figure #15 shows the condition of the pavement before the removal process and the condition of the base after the pavement was removed at Station 371+00. The *before* picture shows that there is considerable faulting of the outside edge of the travel lane which would indicate that there was mixing of the subbase and the OGDC and possible migration of material toward the underdrain. However, the condition of the base (OGDC) in the *after* picture does not show what was expected to be found, probably because of the removal process (Figure #13).

Figure #16 shows that there are indications that there may have been mixing of the sand subbase and OGDC. However, due to the removal process no definite conclusions could be reached to substantiate that there was wide spread mixing of the subbase and the OGDC. Also, no verification could be made that the OGDC had broken down due to traffic loading.

Cores were taken on southbound I-75 to determine the condition of longitudinal cracks that are appearing in the outside wheelpath. The longitudinal cracks are tight and extend from the pavement surface to depths varying from one to nine inches. Complete analysis of the cracks is contained in a Memorandum Report from R. W. Muethel to V. T. Barnhart, January 27, 1998, (Appendix A). It was not possible to determine if the longitudinal cracking in the wheelpath would have had any effect on the cutting of the slots for the proposed dowel bar retrofit as the driving lane on southbound was completely replaced during construction.

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5. 1983 Status Report on I-275 Pavement Performance Research Project 79 F-158, Departmental correspondence from L. T. Oehler to K. A. Allemeier, July 6, 1983.

6. "Concrete Pavement Performance Problems and Foundation Investigation of I-75 from the Ohio Line Northerly to the Huron River," Michigan Department of Transportation, Research Report No. R-1171, June 1981.

FIGURES

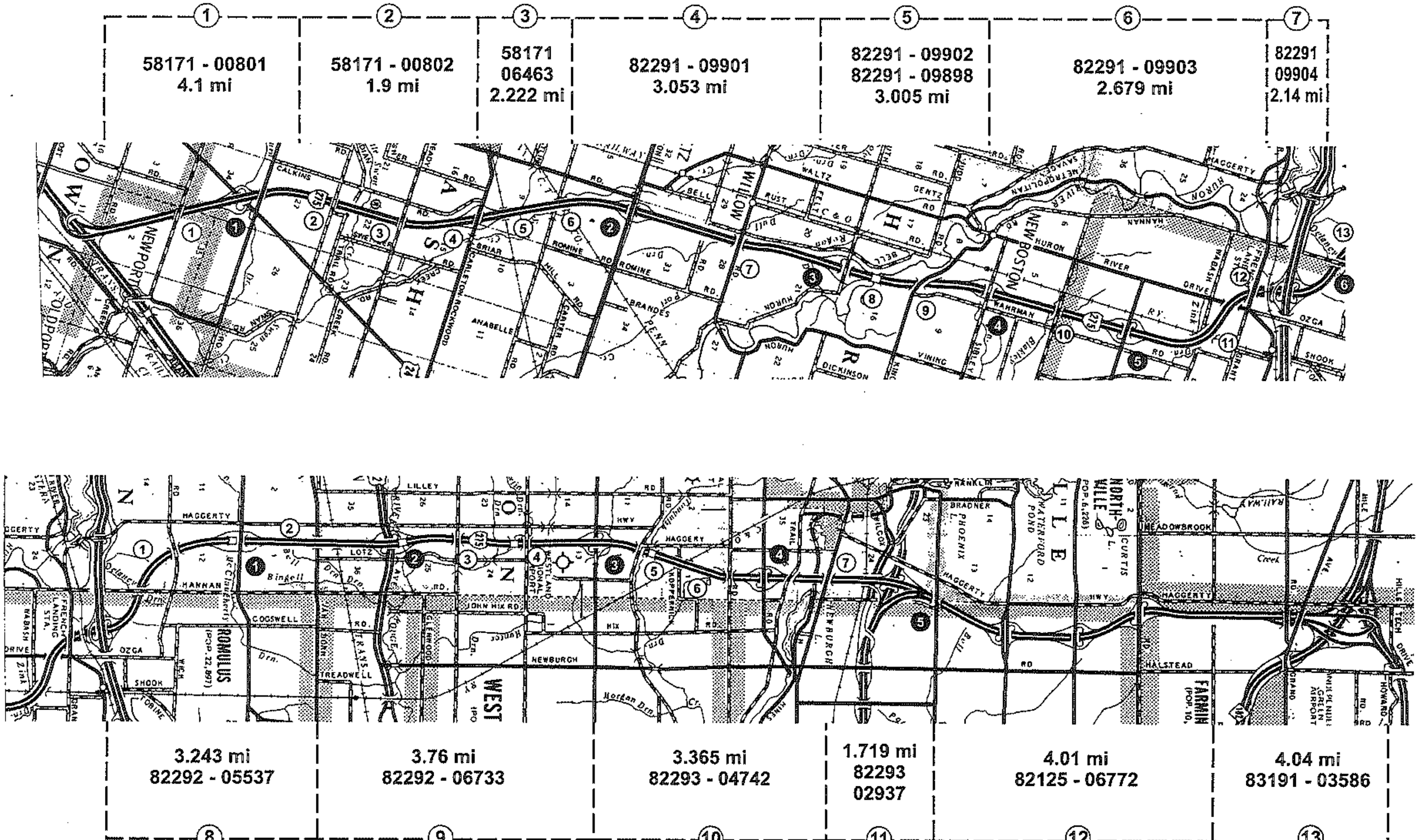

Figure 1.
General location and alignment of I-275 and I-96/I-275 freeway. Mileage, contract numbers and code numbers are also shown.

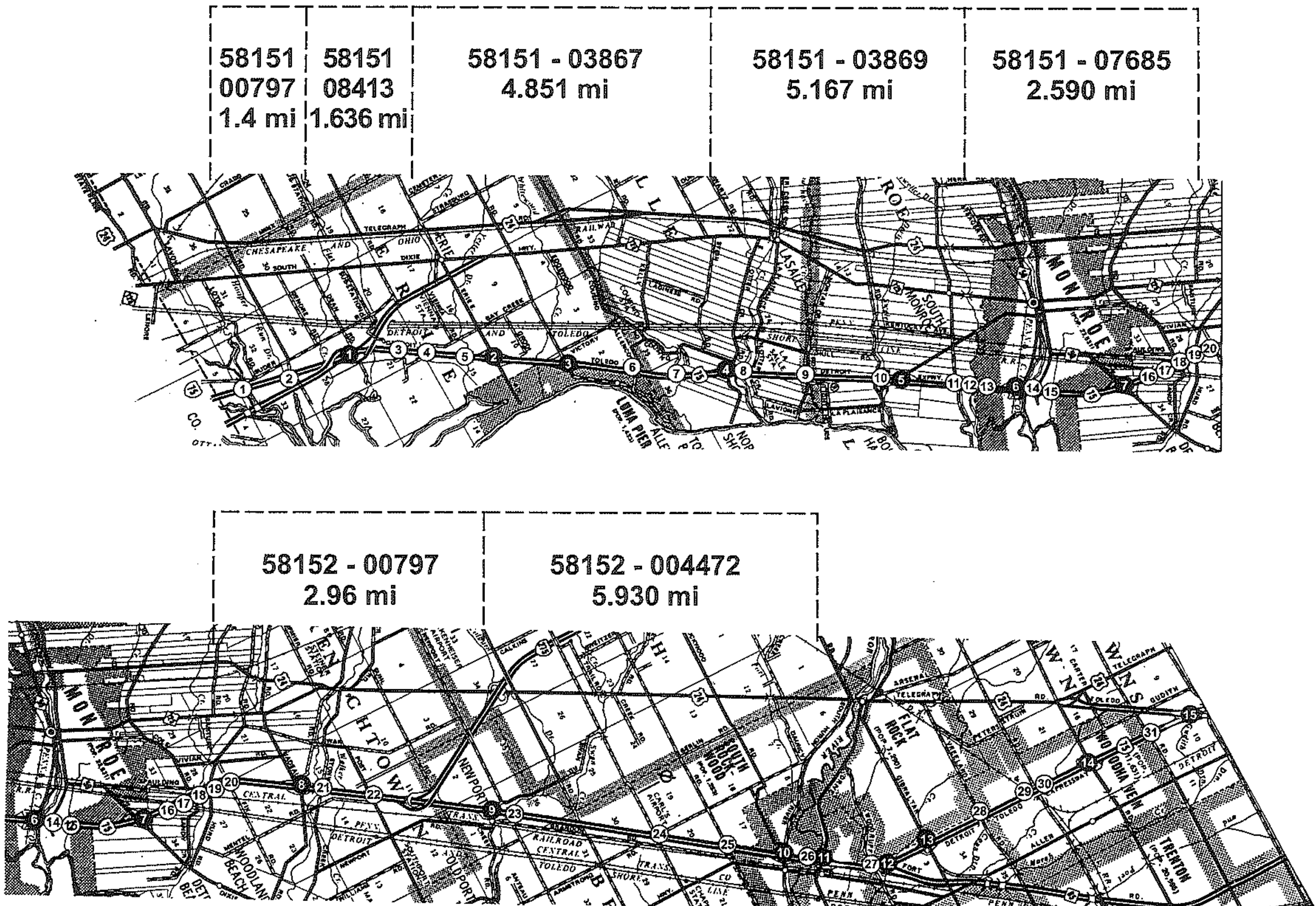

Figure 2.
Projects on I-75 that were widened to 36' between 1973 and 1977.

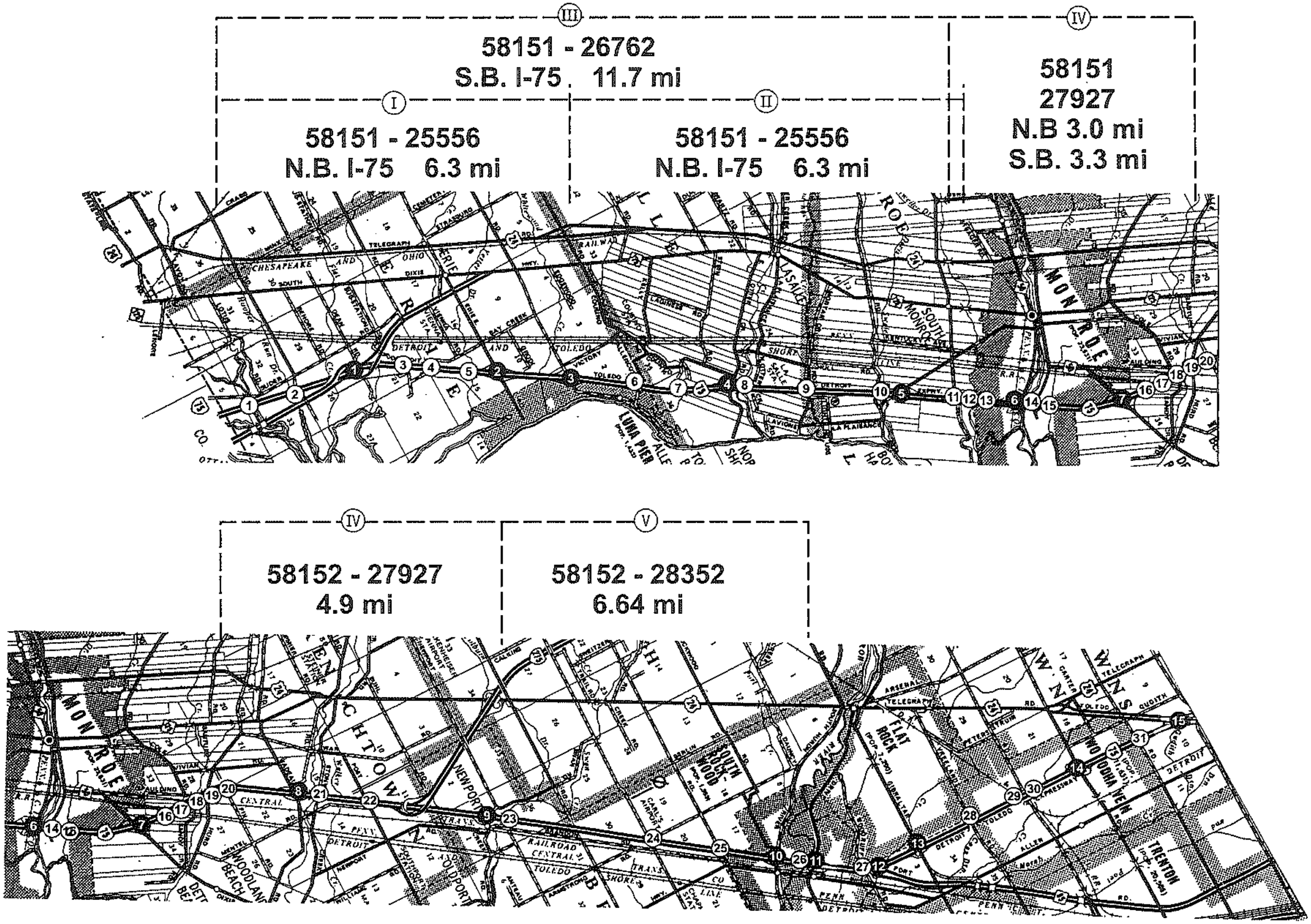

Figure 3.
I-75 projects that were reconstructed between 1984 and 1990.

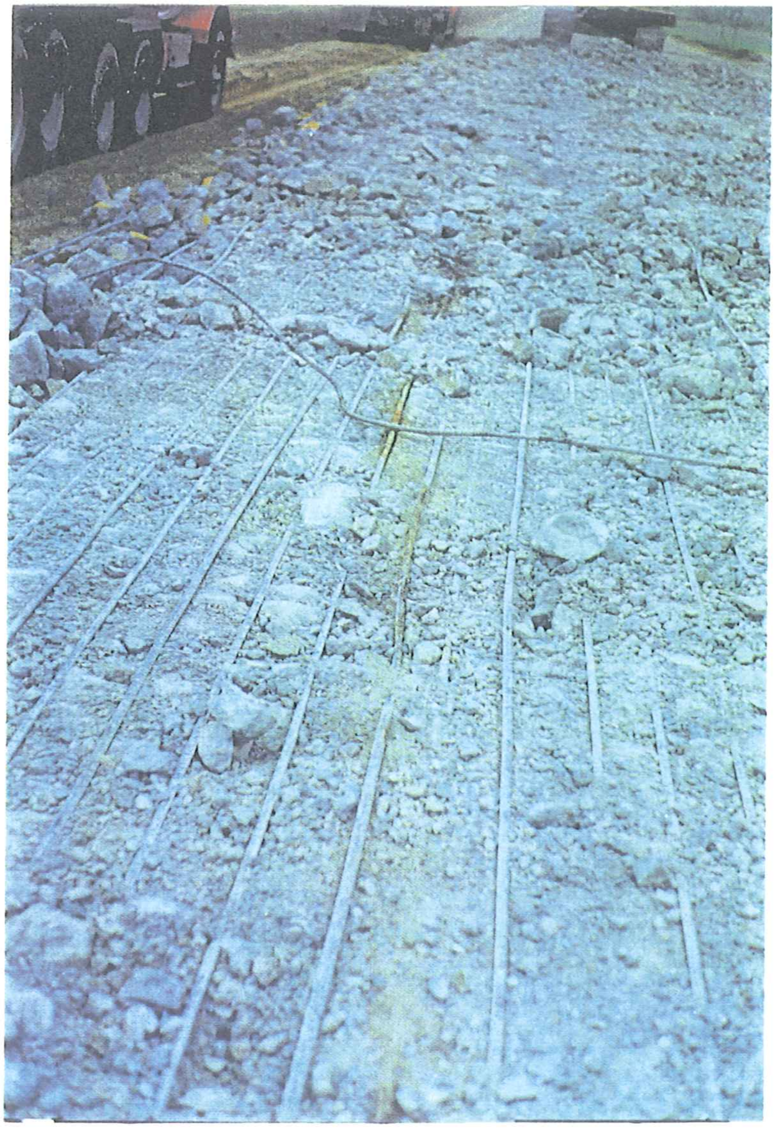

Figure 4
Showing the alignment and spacing of the reinforcing steel bars for the CRC pavement on the reconstruction project on I 275 after the removal of the concrete down to the reinforcement.

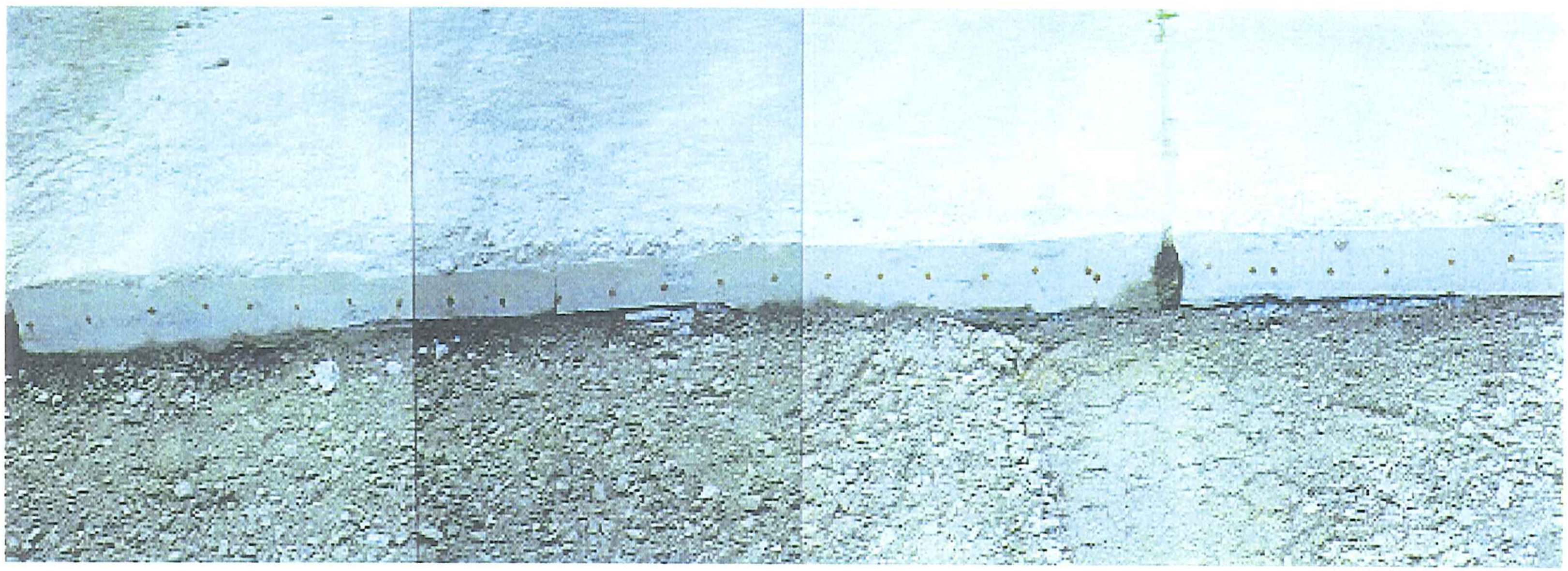

Figure # 5

Showing how depth of the steel reinforcement bars for the CRC Pavement varies across the width of a 12 foot lane at the P.O.B. of the Removal and Replacement Project.

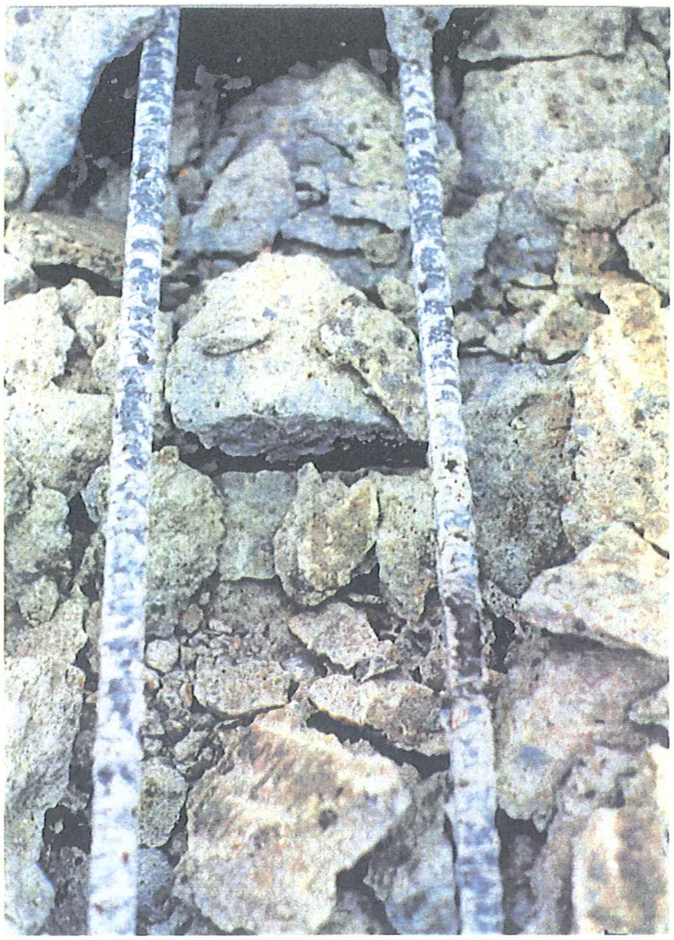

Figure 6
Showing the cement still attached to the reinforcement bars for the CRC pavement after the top layer of the Concrete Pavement had been removed in the Removal and Replacement Project.

Figure 7

Showing how the CRC reinforcement bars followed the Longitudinal Cracks that had developed in the Concrete Pavement.

The Picture on the left shows a crack filled with Bituminous Cold Patch prior to clean out to check location of the reinforcement bars

The Picture on the right shows the crack after being cleaned out down to the reinforcement bars

Figure 8

Showing how in one area the concrete rubblized down to or below the CRC reinforcement steel all across the lane and in another area for approximately 3/4 of the lane width only the top 3/4 inch to 1 inch of the concrete was rubblized and the outside 2 to 3 feet of the lane rubblized down to or below the CRC reinforcement bars.

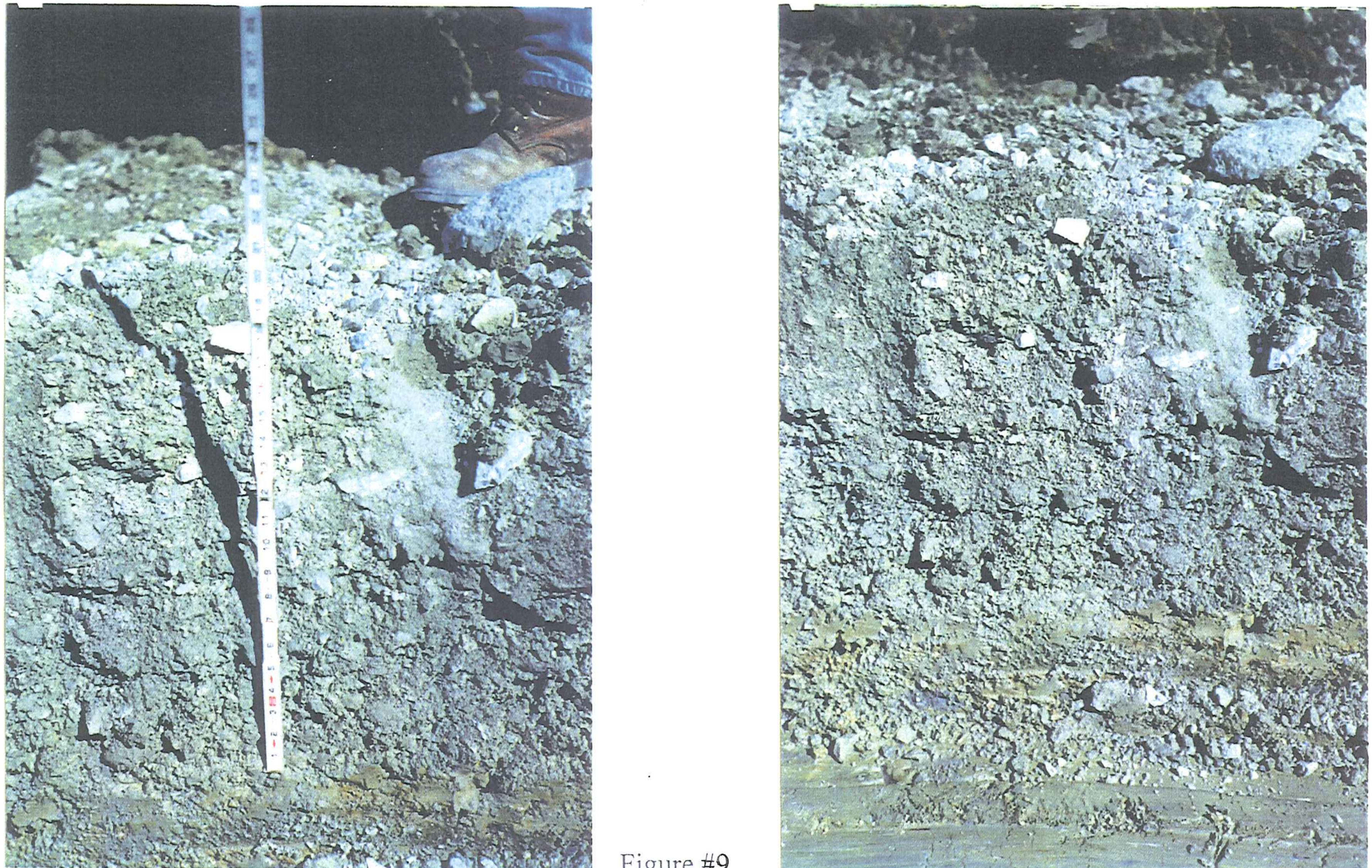

Figure #9

Showing the 22A Lime Stone used as base and subbase for Project #1 on I 275

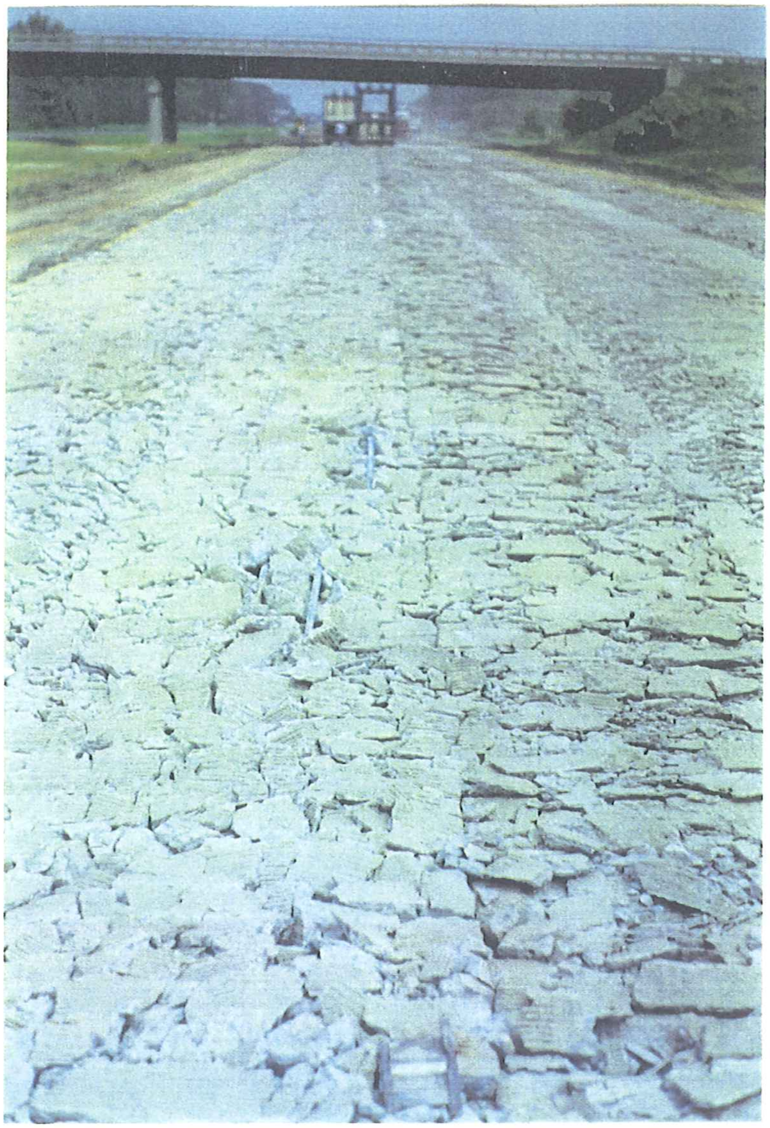

Figure #10

Showing the reinforcement bars bowing up through the broken CRC concrete pavement on the I 275 reconstruction project

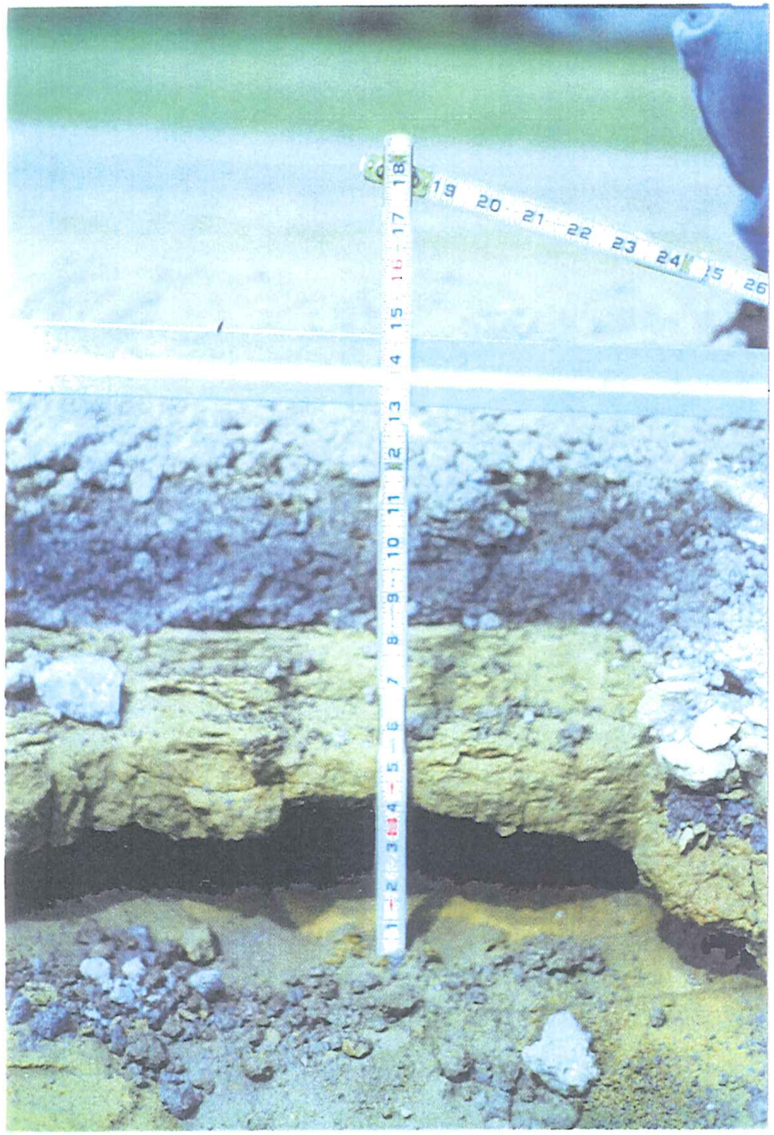

Figure #11

Showing Steel Furnace Slag used as Aggregate Base that had turned to a weak concrete and the sand subbase which had turned to a weak sand stone because of the unhydrated lime component of the slag aggregate which forms a calcium carbonate deposit

The Picture on the left shows the steel furnace slag aggregate 4"deep and the sand subbase 4"-5" deep and an area where some of the sand subbase had washed out from under the sand subbase that had turned to a weak sand stone

The Picture on the right shows a thin layer of the sand subbase that had turned to a weak sand stone

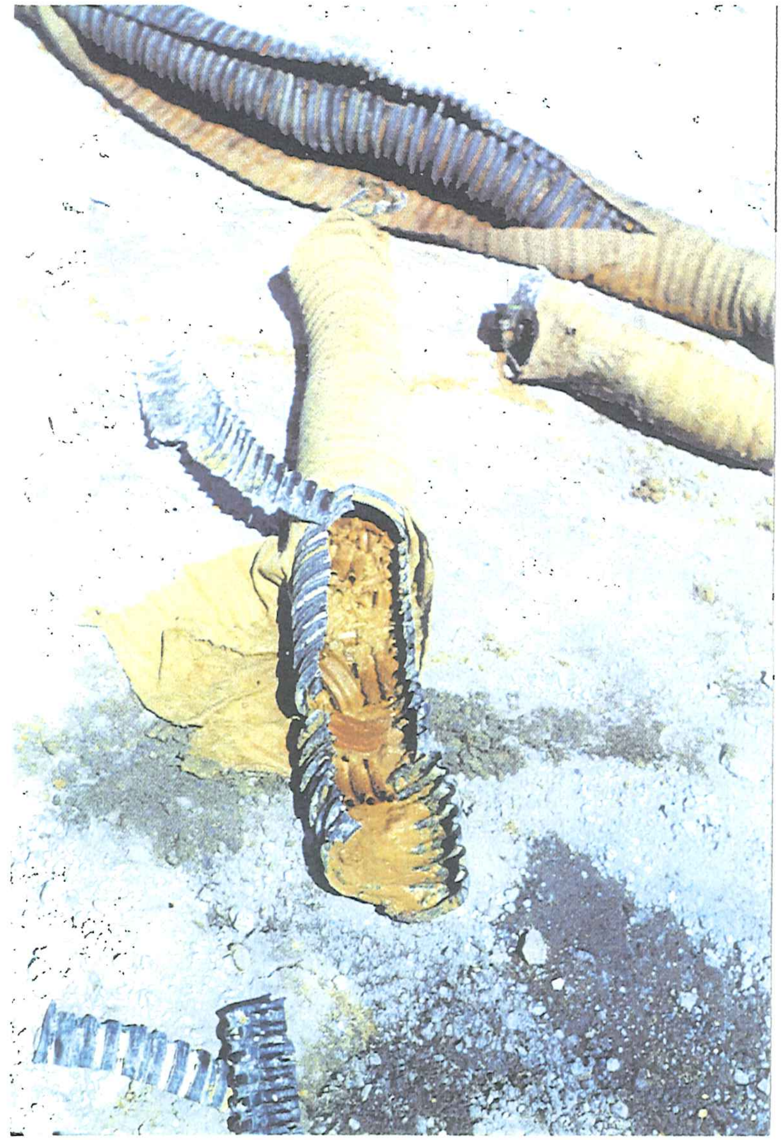

Figure #12
Showing the retrofit edgedrain that was placed on Projects 4 and 5 on I 275 in 1980.

The Picture on the left shows the inside of the pipe and the outside of the sock wrap in 1991.

The Picture on the right shows the inside and outside of the pipe and sock wrap after removal in 1997.

Showing pavement being broken by Guillotine Breaker prior to removal by backhoe

Showing pavement being removed by backhoe and OGDC and broken pieces of concrete being graded by bulldozer

Figure #13

Showing Removal Process for Travel Lane on North Bound I 75

Figure #14

Showing faulted and cracked pavement and the condition of the OGDC and subbase that was observed during a pavement patching project on I 75 in 1994.

Figure #15

Showing faulted and cracked pavement at station 371+00 before pavement removal and the condition of the OGDC after the removal of the pavement

Figure #16

Showing indication that there may have been mixing of the OGDC and the sand subbase