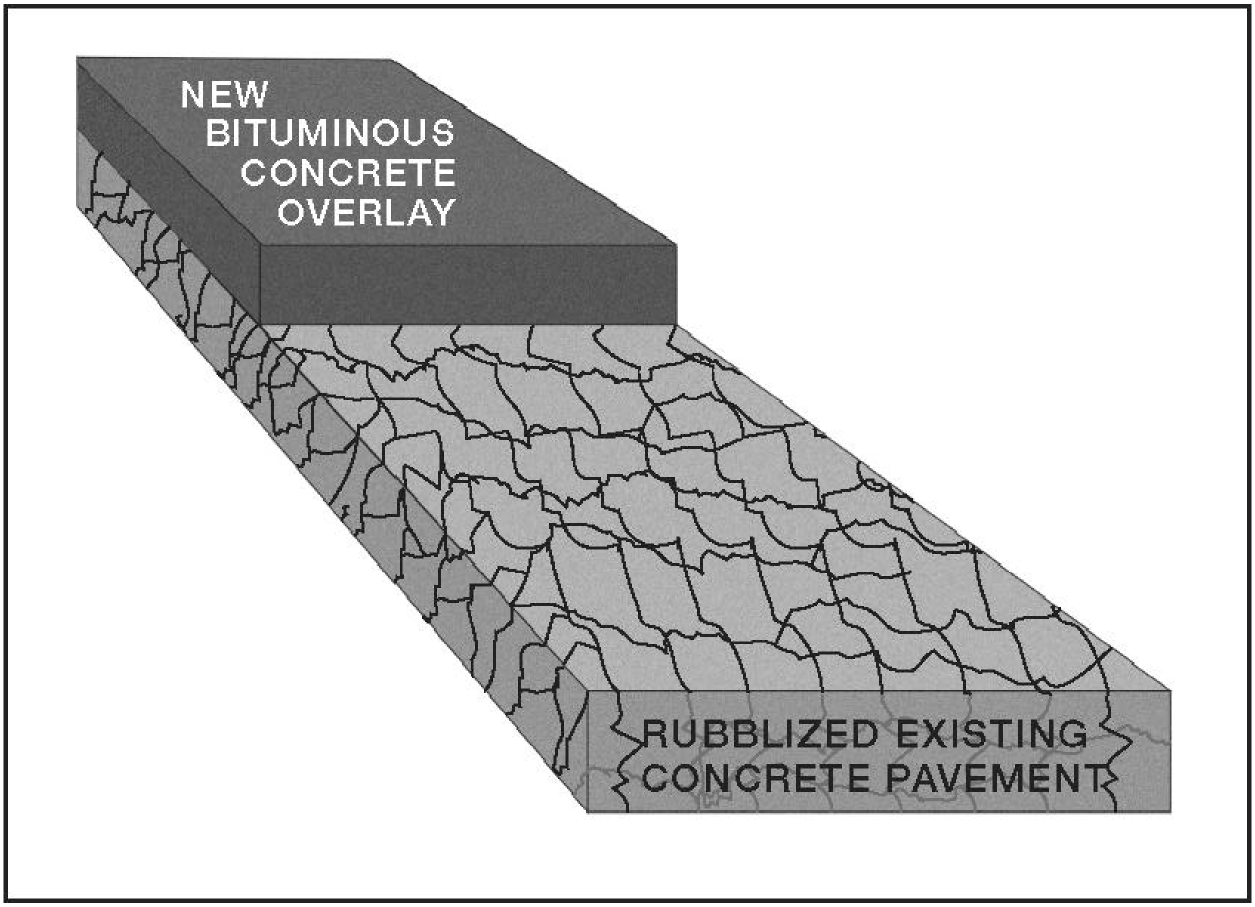
RUBBLIZING WITH BITUMINOUS CONCRETE OVERLAY – 10 YEARS' EXPERIENCE IN ILLINOIS



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16. Abstract

About 16,000 out of 17,000 miles of the Illinois Department of Transportation's pavements were originally constructed as either jointed plain concrete, jointed reinforced concrete, or continuously reinforced concrete. Many of these pavements have been rehabilitated or are in need of rehabilitation. Typical repair of all portland cement concrete pavements is to repair the broken and D-cracked sections with patches and overlay with bituminous concrete. Bituminous concrete overlays of PCC pavements usually begin to fail at the reflected joints and patched areas of the old concrete pavement, in addition to areas where the underlying concrete has continued to deteriorate. Rubblization eliminates joints and cracks that may reflect through a bituminous concrete overlay. Ten projects using the rubblization method have been constructed in Illinois, seven of which incorporated experimental features and were closely monitored. The construction and performance of these seven projects are presented in this report. Performance has been very good, with less reflective cracking than on adjacent patch and overlay sections.

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RUBBLIZING WITH BITUMINOUS CONCRETE OVERLAY – 10 YEARS' EXPERIENCE IN ILLINOIS

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DISCLAIMER

The contents of this report reflect the views of the author, who is responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of IDOT. This report does not constitute a standard, specification, or regulation at IDOT.

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INTRODUCTION

Background

The Illinois Department of Transportation (IDOT) maintains approximately 17,000 centerline miles of pavements. About 16,000 miles of IDOT's pavements were initially constructed as either jointed plain concrete (JPC), jointed reinforced concrete (JRC), or continuously reinforced concrete (CRC). Many of these pavements have reached the end of their service lives and have been rehabilitated. More than 95 percent of the Department's annual budget is dedicated to system maintenance, extending the life of the existing system.

Typical rehabilitation of all portland cement concrete (PCC) pavements is repair of the broken and D-cracked sections with patches, and overlay with bituminous concrete. Many jointed concrete pavements require extensive patching at the joints. Patching is quite costly and time consuming.

Bituminous concrete overlays of PCC pavements usually begin to fail at the reflected joints and patched areas of the old concrete pavement. Failures also occur in areas where the underlying concrete has continued to deteriorate, requiring additional costly full-depth patches.

Rubblization is a process in which the existing concrete pavement is broken into small (less than 9 inches) pieces, and the concrete/steel bond is broken. Rubblization eliminates joints and cracks that may reflect through a bituminous concrete overlay. Patching is not needed, because the pavement is used as a subbase. The time required for pavement removal, drilling and placing dowels, and curing of PCC patches, is eliminated.

The Department has investigated other methods of concrete pavement rehabilitation to prevent reflective cracking, primarily reflective crack control treatments (both area and strip) and crack and seat. These techniques have had limited success (1, 2, 3, 4). Open-graded base courses placed on top of the concrete and sand anti-fracture layers have also been constructed, but the results are inconclusive at this time.

Experimental Features Projects

As of 2000, ten projects had been constructed in Illinois incorporating the rubblizing method. Seven of the ten had experimental features and their performance has been closely monitored. These seven projects are shown in Figure 1 and are as follows:

- Interstate 57 constructed in 1990.
- Illinois Route 38 constructed in 1994.
- Interstate 55 Frontage Road constructed in 1994.
- Interstate 57 constructed in 1996.
- Interstate 70 constructed in 1997.
- Interstate 57 constructed in 1997.
- Interstate 74 constructed in 1999.

To date, none of the ten projects have been rehabilitated.

Pavement designs were selected to provide a spectrum of thicknesses through a variety of traffic levels. After the projects were constructed, deflection testing was conducted annually on all the projects. The analysis of the deflection data was used to formulate a design procedure for future projects.

All projects were evaluated to determine if underdrains were present, and if they were functioning. Functioning underdrains are beneficial for providing drainage during construction, as well as to guard against moisture damage to the bituminous concrete overlay after construction.

Two types of pavement breakers were used to rubblize the pavements. They are described in the following section. The data collection methods used to monitor the projects, construction and performance details on each of the seven projects, and the current status of rubblizing in Illinois are included in this report.

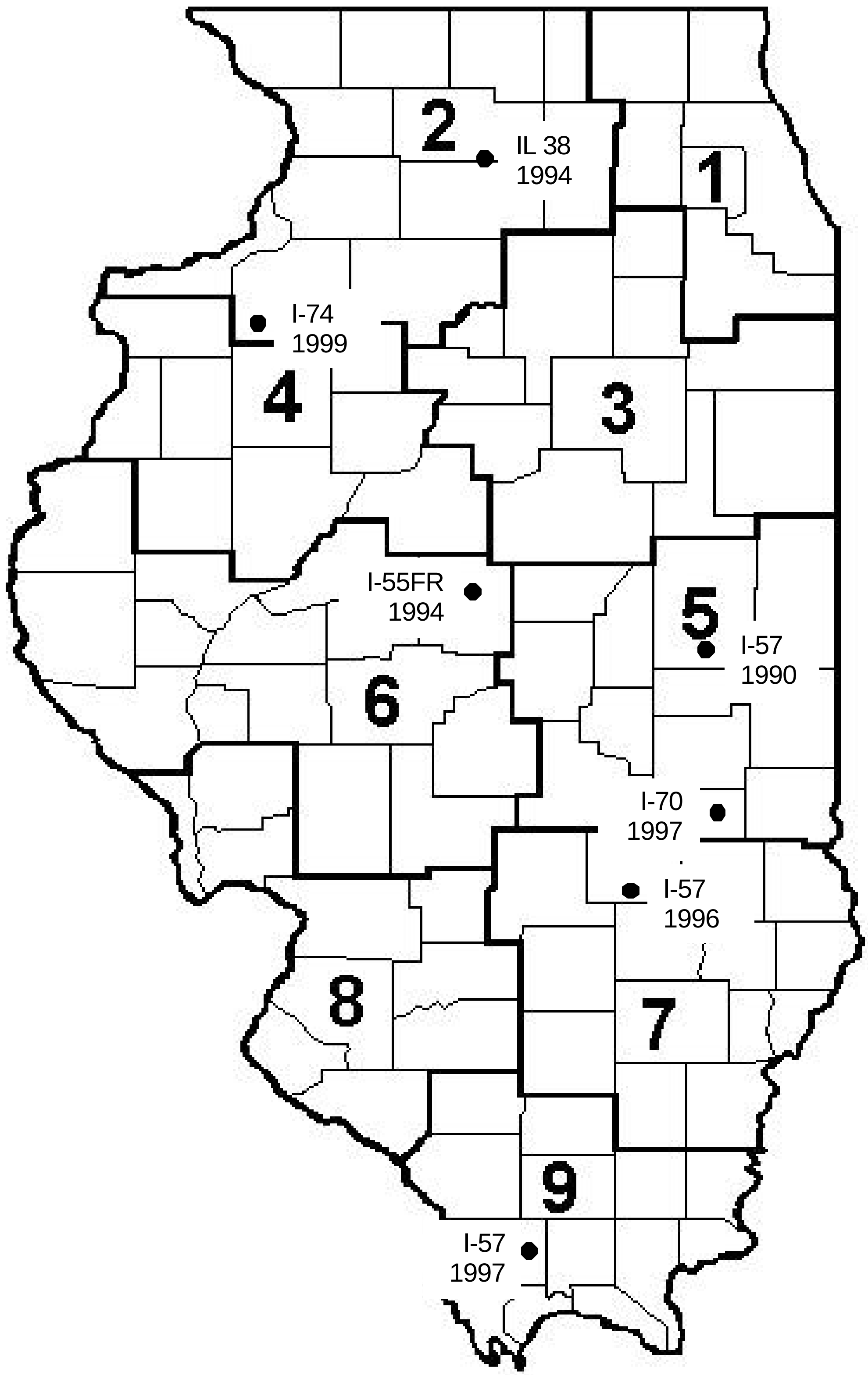

Figure 1. Locations and Construction Year of Monitored Rubblization Projects in Illinois.

RUBBLIZING EQUIPMENT

Two types of pavement breakers have been used for rubblizing concrete pavement. They are the resonant frequency breaker and the multi-head breaker (MHB).

Resonant Frequency Breaker

The resonant frequency breaker (see Figure 2) is a self-propelled unit that utilizes high frequency, low amplitude impacts with a shoe force of 2,000 pounds to fracture the PCC pavement. The shoe, or hammer, is located at the end of a pedestal, which is attached to a beam and counter weight. The breaking principle is that a low amplitude, high frequency resonant energy is delivered to the concrete slab, resulting in high tension at the top. This causes the slab to fracture on a shear plane, inclined at about 35 degrees from the pavement surface. The shoe, beam size, operating frequency, loading pressure and speed of the machine can all be varied.

Figure 2. Resonant Frequency Breaker.

The breaking operation begins at the centerline and proceeds to the outside edge of the pavement. The breaking pattern is approximately 8 inches wide, and requires 18 to 20 passes to break a 12-foot lane width. The rate of production depends on the type of base/subbase material, and is approximately 1.0 lane-mile per day.

The resonant breaker has very heavy wheel loads of 20,000 pounds. The broken pavement, shoulder, and subgrade must be adequate to support multiple passes of the equipment. The resonant breaker encroaches 3 to 5 feet into the adjacent lane to rubblize pavement near the center line. The pavement section/shoulder must be structurally adequate for traffic to be moved 7 to 8 feet from the centerline and onto the shoulder.

Multi-Head Breaker

The MHB is a self-propelled unit with multiple drop-hammers mounted at the rear of the machine. The hammers are set in two rows, and strike the pavement approximately every 4.5 inches. The hammers have variable drop heights and variable cycling speeds (see Figure 3).

Figure 3. Multi-Head Breaker.

The equipment has the ability to break pavement up to 13 feet wide, in one pass. The rate of production depends on the type of base/subbase material, and can be up to 1.4 lane-miles per day.

The Z-pattern steel grid roller, a vibratory roller with a grid pattern, must be used in conjunction with the MHB to complete the breaking process. The Z-pattern grid is attached transversely to the drum surface (see Figure 4). This roller further breaks flat and elongated material into more uniform pieces. The vibratory roller is self-propelled, with a minimum gross weight of 10 tons.

Figure 4. Z-Pattern Steel Grid Roller.

DATA COLLECTION METHODS

The data collection methods used to measure performance of the rubblized projects include Condition Rating Survey (CRS) values and visual distress surveys, International Roughness Index (IRI) and rutting, and Falling Weight Deflectometer (FWD) data. These performance measures are described in detail in the following sections.

CRS and Visual Distress Surveys

The CRS is performed on every pavement section every two years by the Department. The rating ranges from 9.0 to 1.0, with 9.0 being new construction and 1.0 representing total failure of the pavement. This rating is used to decide when sections of roadway need rehabilitation.

Visual distress surveys were conducted on these projects by personnel from the Bureau of Materials and Physical Research. The distress collection methodology is similar to the Strategic Highway Research Program's (SHRP) "Distress Identification Manual for the Long-Term Pavement Performance (LTPP) Project." (5) No distinction was made between reflective cracking and other transverse or longitudinal cracking.

IRI and Rutting Data

Roughness and rutting data were collected on the rubblized projects using the Department's Video Inspection Vehicles (VIVs). The Department began using the VIVs in 1993. This device measures surface roughness in inches per mile, and rutting in inches. The IRI and rutting values are calculated from the data collected with the VIVs. The data included in this report are averages for each section.

For both IRI and rutting, the lower the value, the better the ride quality. An IRI around 60 inches per mile is typical for new bituminous concrete pavements. Rutting should be 0.0 inches at the time of construction.

FWD Data

Deflection data were collected on the rubblized projects using IDOT's Dynatest 8002 FWD, a non-destructive loading device capable of exerting a load impulse comparable in magnitude and duration to moving truck loads.

Data analyzed include deflection under the load, deflection basin area, and subgrade resilient modulus (E_{RI}). Deflection data under the load were normalized to reflect a 9,000-pound load to allow for direct comparison of results. Deflections under 10 mils for bituminous concrete pavements are considered excellent. The lower the deflection, the stiffer the pavement cross section.

The deflection basin area represents the ability of the pavement to spread an applied load. The units for deflection basin area are inches, because true area is divided by the deflection under the load to allow for comparison. Areas of approximately 25 inches are typical for bituminous concrete pavements. The higher the deflection basin area, the greater the load-spreading ability of the pavement.

Subgrade resilient modulus (E_{RI}) values were calculated using concepts and algorithms developed at the University of Illinois (6). A higher E_{RI} represents a more stable subgrade. An E_{RI} greater than 10 ksi is considered good support for bituminous concrete pavements.

The deflection data presented in the tables for each pavement section are averages for the section in the year of deflection testing. The temperature shown in the tables is taken at mid-depth of each pavement section.

INTERSTATE 57 CONSTRUCTED 1990

An interstate route was selected for Experimental Features IL 90-01 and IL 90-02 in 1990. A SHRP LTPP SPS-6 experiment was incorporated into the section. The project was constructed under Contract #90128. The following methods used in the project will be the focus of this report: (1) a control section of full-depth PCC patching with a 3.25-inch bituminous concrete overlay, (2) rubblization with a 6-inch bituminous concrete overlay, and (3) rubblization with an 8-inch bituminous concrete overlay.

Project Background

The selected route's location, cross section, traffic, preconstruction condition, and test section description are contained in the following sections.

Location, Cross Section, and Traffic

The section is located on northbound Interstate 57 from US 45 to four miles north of Pesotum, 13.5 miles south of Champaign (see Figure 5). The existing pavement was a 10-inch thick JRC pavement, with a joint spacing of 100 feet, on a 6-inch granular subbase constructed in 1965. The 1987 Average Daily Traffic (ADT) was 13,700 with 20.5 percent trucks.

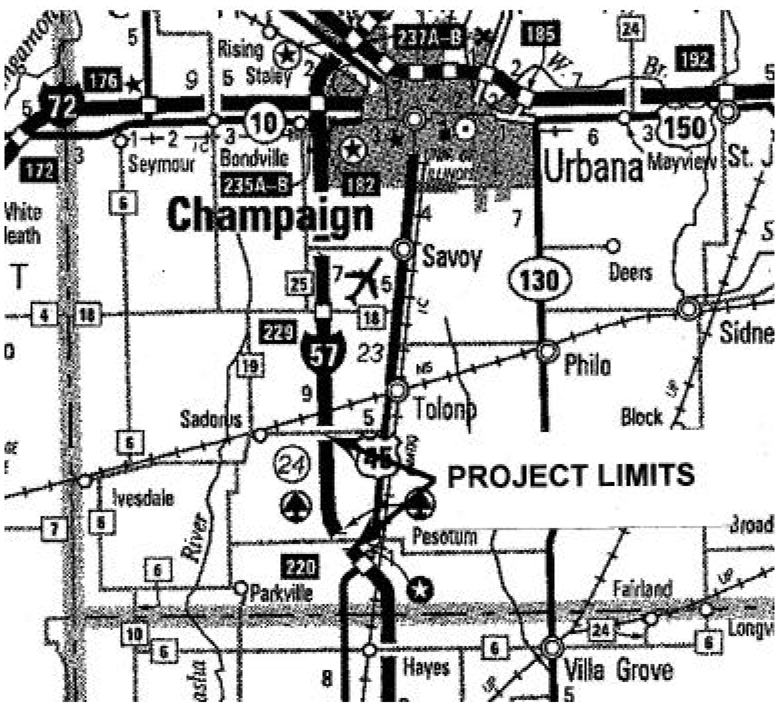

Figure 5. Location of I-57 Project Constructed in 1990.

Preconstruction Condition

The CRS value in 1988 was 6.0; the pavement was considered to be in a fair condition and approaching the need for rehabilitation. Mid-panel cracks were common and faulting of 0.125- to 0.25-inch was prevalent. Minor spalling and some pumping of fines were also present.

Test Section Description

The following control and test sections were constructed as part of this contract:

- Station 306+14 to 311+14: Standard patching with a 3.25-inch bituminous concrete overlay (control).
- Station 335+95 to 340+95: Rubblization with an 8-inch bituminous concrete overlay.
- Station 342+95 to 347+95: Rubblization with a 6-inch bituminous concrete overlay.

Construction

The project was constructed under traffic in August 1990. The equipment used, construction sequence, and challenges encountered are discussed in the next sections.

Equipment

The machine used to rubblize the existing JRC pavement was a resonant frequency breaker, specifically the PB-4. Because the rubblized sections were so short, no generalities can be made about production rate.

Sequence

The passing lane was rehabilitated first. Full-depth PCC patching in the control section was performed concurrently with rubblizing of the two test sections. Next, all lifts of binder were placed on the passing lane and inside shoulder. Binder lift thicknesses were 1.75 inches, 4.5 inches, and 6.5 inches for the control, rubblization with a 6-inch overlay, and rubblization with an 8-inch overlay, respectively. Traffic was then switched to the passing lane. The driving lane's control section was patched, and the test sections were rubblized concurrently (see Figure 6). All lifts of binder were then placed on the driving lane and outside shoulder. The 1.5-inch surface course was placed on all sections in the last operation.

Challenges

Rubblizing the pavement under traffic presented a large challenge. When working near the centerline, the equipment encroached on the adjacent travel lane. Traffic was required to drive partially on the shoulder. The shoulders of this pavement were in an acceptable structural condition, so failures did not occur. There was no place for disabled vehicles to move out of the traffic flow, potentially impeding traffic.

Performance

Performance has been monitored since construction. Items examined include CRS values and visual distress surveys, IRI, rutting, and FWD testing.

Figure 6. Passing Lane Binder Complete,
Driving Lane Begun (I-57 1990).

CRS Values and Visual Distress Surveys

The CRS value in 2000 for test and control sections was 6.9, considered good. The sections have been surveyed for deterioration most years since construction. The distress surveys were conducted by the Regional Coordinator for the SHRP LTPP program. Inconsistencies from year to year may be due to differences in surveyors.

Standard Patching with a 3.25-Inch Bituminous Concrete Overlay (Control)

The distresses for the control section are summarized in Table 1.

Table 1. Summary of Visual Distress Surveys on Control Section (I-57 1990).

			Age of Pavement (Years)					
Distress	Units	Severity	1	2	3	5	8	9
Longitudinal Cracking	Feet/ Lane Mile	Low	10.6	876	713	203	1700	866
		Medium	0	0	0	121	192	2640
		High	0	0	0	0	0	0
Transverse Cracking	Number/ Lane Mile	Low	31.7	31.7	21.1	37.0	89.8	73.9
		Medium	0	5.3	10.6	10.6	15.8	31.7
		High	0	0	5.3	10.6	0	0

Rubblization with a 6-Inch Bituminous Concrete Overlay

The distresses for the section that was rubblized and overlaid with 6 inches of bituminous concrete are summarized in Table 2. Figure 7 shows the pavement in 1996.

Table 2. Summary of Visual Distress Surveys on Rubblize and 6" Overlay (I-57 1990).

			Age of Pavement (Years)		
Distress	Severity	Units	2	5	8
Longitudinal Cracking	Low	Feet/Lane Mile	260	0	338
	Medium	Feet/Lane Mile	0	0	0
	High	Feet/Lane Mile	0	0	0
Transverse Cracking	Low	Number/Lane Mile	0	10.6	121
	Medium	Number/Lane Mile	0	0	0
	High	Number/Lane Mile	0	0	0

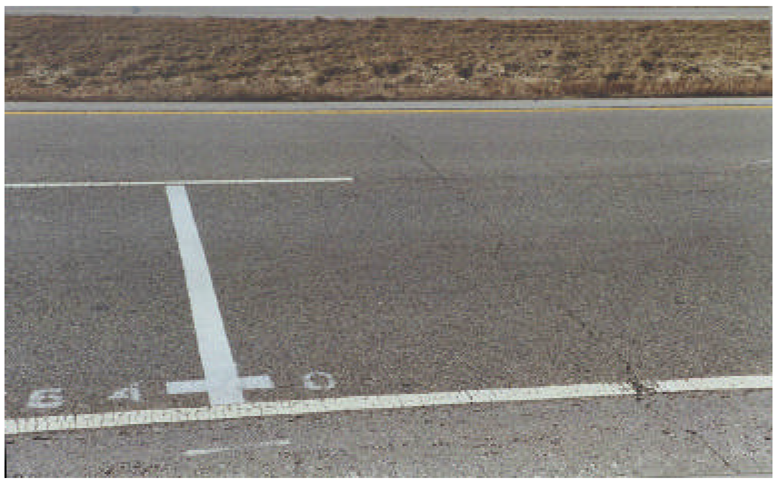

Figure 7. Rubblize and 6" Overlay in 1996 (I-57 1990).

Rubblization with an 8-Inch Bituminous Concrete Overlay

The distresses for the section that was rubblized and overlaid with 8 inches of bituminous concrete are summarized in Table 3.

Transverse cracking began five years later than the control section on the 6-inch overlay of rubblized pavement and eight years later on the 8-inch overlay of rubblized pavement.

<u>IRI and Rutting</u>

The IRI and rutting data have been collected every year since construction. The IRI and rutting data for the two test sections and the control section are contained in Table 4. The IRI and rutting are similar on all sections and are acceptable after 10 years of service.

Table 3. Summary of Visual Distress Surveys on Rubblize and 8" Overlay (I-57 1990).

			Age of Pavement (Years)			
Distress	Severity	Units	2	5	8	9
Block Cracking	Low	Feet/Lane Mile	0	0	0	1798
	Medium	Feet/Lane Mile	0	0	0	0
	High	Feet/Lane Mile	0	0	0	0
Longitudinal Cracking	Low	Feet/Lane Mile	0	0	210	13.7
	Medium	Feet/Lane Mile	0	0	0	2640
	High	Feet/Lane Mile	0	0	0	0
Transverse Cracking	Low	Number/Lane Mile	0	0	132	169
	Medium	Number/Lane Mile	0	0	0	0
	High	Number/Lane Mile	0	0	0	0

Table 4. IRI and Rutting Data (I-57 1990).

	Control		Rubblize & 6" Overlay		Rubblize & 8" Overlay	
Year	IRI (in./mi.)	Rut (in.)	IRI (in./mi.)	Rut (in.)	IRI (in./mi.)	Rut (in.)
1991	95	0.07	76	0.12	81	0.11
1992	71	0.06	70	0.11	75	0.11
1993	79	0.04	74	0.07	76	0.08
1994	96	0.02	74	0.06	80	0.03
1995	87	0.07	70	0.13	71	0.14
1996	92	0.08	78	0.10	74	0.06
1997	112	0.08	79	0.14	79	0.12
1998	96	0.09	78	0.13	72	0.14
1999	126	0.10	79	0.15	72	0.13
2000	92	0.13	78	0.14	64	0.16

FWD

FWD data have been collected most years since the construction of the pavement in 1990. The average deflection data are summarized in Table 5. The deflections, area, and E_{RI} have improved since construction in 1990. This improvement is likely the result of the hardening of the asphalt cement and the seating of the rubblized layer.

Table 5. FWD Data for All Sections (I-57 1990).

Year	Section	Temp. (°F)	Deflection (mils)	Area (in.)	E_{RI} (ksi)
1990	Control	–	–	–	–
1990	Rubb. 6"	73	13.3	24.1	5.6
1990	Rubb. 8"	77	12.0	24.4	6.4
1991	Control	–	–	–	–
1991	Rubb. 6"	95	12.6	22.5	7.9
1991	Rubb. 8"	95	9.1	24.0	9.2
1993	Control	–	–	–	–
1993	Rubb. 6"	73	8.5	24.4	10.5
1993	Rubb. 8"	73	6.1	26.1	12.1
1994	Control	–	–	–	–
1994	Rubb. 6"	88	10.8	22.8	9.6
1994	Rubb. 8"	88	7.6	24.6	11.0
1995	Control	–	–	–	–
1995	Rubb. 6"	89	10.2	21.9	11.0
1995	Rubb. 8"	89	7.3	24.1	11.9
1996	Control	50	3.8	31.9	9.3
1996	Rubb. 6"	50	5.4	26.4	13.1
1996	Rubb. 8"	50	7.2	25.2	11.6
1997	Control	73	4.2	30.2	9.4
1997	Rubb. 6"	73	7.9	24.3	11.2
1997	Rubb. 8"	73	5.5	26.9	12.3
1998	Control	83	4.0	30.5	10.3
1998	Rubb. 6"	83	8.7	23.0	11.6
1998	Rubb. 8"	83	6.1	24.8	12.9
1999	Control	44	4.1	31.2	5.5
1999	Rubb. 6"	44	6.5	25.2	10.3
1999	Rubb. 8"	44	4.7	27.5	11.8

Project Summary

The only construction challenge related to using the PB-4 while the interstate was open to traffic. The resonant frequency breaker was difficult to work with while maintaining traffic, due to the encroachment of the machine into the adjacent lane. Looking at performance, the rubblization with an 8-inch overlay had the least cracking through 8 years. Neither rubblization section had any medium or high severity transverse cracking through 8 and 9 years. Roughness and rutting are comparable between all three sections. Structural capacity, as determined by the FWD, is acceptable on all sections.

ILLINOIS ROUTE 38 CONSTRUCTED 1994

A non-interstate route was selected for Experimental Feature IL93-05 in 1994. The project was constructed under Contract #84519 using the following methods: (1) rubblization with a 7-inch bituminous concrete overlay, (2) open-graded base course (OGBC) with a 4-inch bituminous concrete overlay, (3) minimal PCC patching with a thick (4-inch) bituminous concrete overlay, and (4) standard PCC patching with a standard (2.5-inch) bituminous concrete overlay.

Project Background

The selected route's location, cross section, traffic, preconstruction condition, and test section description are contained in the following sections.

Location, Cross Section, and Traffic

The project is located on Illinois Route 38 in Lee and Ogle Counties. The pavement begins in Ashton and ends approximately two miles west of Rochelle (see Figure 8). According to contract plans, the existing pavement was constructed as a 9-inch JRC pavement with welded wire fabric and 100-foot joint spacing. The pavement had two 12-foot lanes and 3-inch bituminous concrete shoulders on 6-inches aggregate base course that were added to support traffic during construction. In 1993, the section had an ADT of 2,500 vehicles with 8 percent trucks.

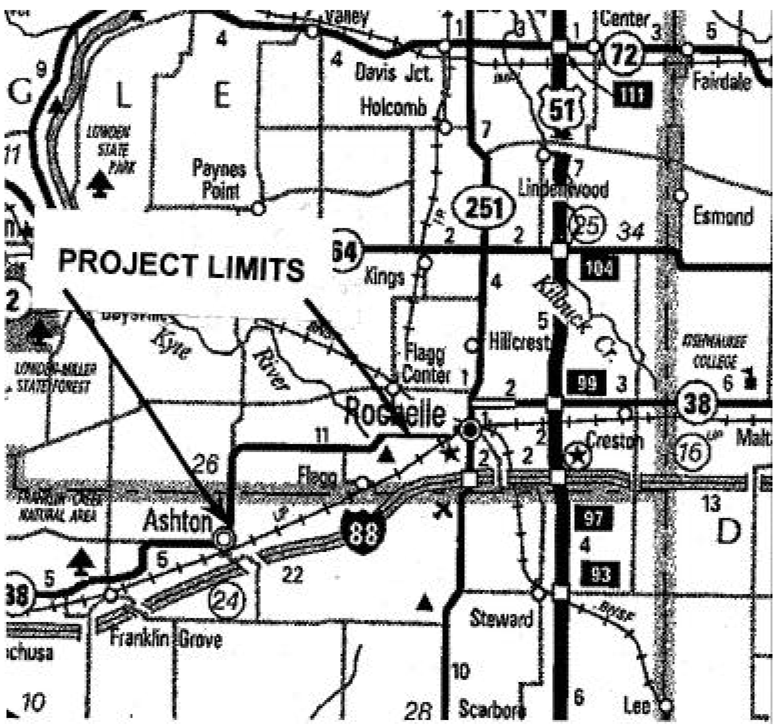

Figure 8. Location of IL 38 Project Constructed in 1994.

Preconstruction Condition

The CRS value and existing distresses were obtained to determine the existing condition of the pavement. The CRS value of this section averaged 4.4 in 1990. This is considered pavement in poor condition. Extensive transverse cracking and some D-cracking were evident on this pavement. In addition, the centerline joint was highly distressed. Figure 9 shows the preconstruction condition of this pavement.

Figure 9. Preconstruction Condition Background,
Rubblizing Foreground (IL 38 1994).

Test Section Description

The following three test sections and one control section were constructed as part of this contract:

- Rubblization with a 7-inch bituminous concrete overlay (changed from 6 inches during construction).
- OGBC with a 4-inch bituminous concrete overlay.
- Minimal PCC patching with a thick (4-inch) bituminous concrete overlay.
- Standard PCC patching with a standard (2.5-inch) bituminous concrete overlay (control).

These sections are described in the following paragraphs.

Rubblization with a 7-Inch Bituminous Concrete Overlay

From station 780+35 to 920+50, the existing JRC pavement was rubblized and used as a subbase. A 7-inch bituminous concrete overlay was constructed on top of the rubblized pavement. An overlay thickness of 6 inches was designed, but 1 inch was added to the first binder lift due to construction problems. Underdrains were added to the pavement cross section. Preliminary patching schedules indicated 12.7 percent of the pavement should have been patched if the standard rehabilitation had been done.

OGBC with a 4-Inch Bituminous Concrete Overlay

From station 920+50 to 1025+60, a 3-inch OGBC was constructed on top of the existing pavement after the centerline was milled partial-depth and refilled with leveling binder, and cracks were filled. A 4-inch bituminous concrete overlay was constructed on top of the OGBC. Underdrains were added to the pavement cross section. Preliminary patching schedules indicated 7.3 percent of the pavement should have been patched if the standard rehabilitation had been done. The contract allowed for PCC patching 1.4 percent of the pavement.

Minimal PCC Patching with a Thick Bituminous Concrete Overlay

From station 1025+60 to 1125+00, a 4-inch bituminous concrete overlay was constructed on top of the existing pavement. The centerline was milled partial-depth and filled with leveling binder, and cracks were filled in preparation for the overlay. Preliminary patching schedules indicated 6.5 percent of the pavement should have been patched if the standard rehabilitation had been done. Patching was performed on 3.9 percent of the pavement.

Standard PCC Patching with a Standard Bituminous Concrete Overlay (Control)

From station 1125+00 to 1190+00, a standard 2.5-inch bituminous concrete overlay was constructed on top of the existing pavement. Preliminary patching schedules indicated 3.3 percent of the pavement should have been patched. The contract allowed for PCC patching 3.5 percent of the pavement.

Construction

The project was constructed under traffic in August 1994. The equipment used, construction sequence, and challenges encountered are discussed in the next sections.

Equipment

Only the rubblized section required specialized equipment. The machine used to rubblize the existing JRC pavement was a PB-4 resonant breaker, operated by Resonant Machines, Inc.

Sequence

For all sections, pipe underdrains and underdrain outlet pipes were installed at the edge of pavement at the start of construction. The remaining construction sequence is detailed in the following sections.

Rubblization with a 7-Inch Bituminous Concrete Overlay

Rubblizing of the existing concrete pavement proceeded after underdrain installation. About 0.25 to 0.50 two-lane mile was rubblized per day. About 20 passes were needed to completely rubblize each traffic lane. Rubblization progressed from one shoulder to the other shoulder. Figure 10 shows the rubblizing process. The rubblized pavement was compacted using both pneumatic and vibratory rollers.

Figure 10. Rubblizing Process (IL 38 1994).

The bituminous concrete overlay consisted of two binder lifts and one surface lift. The binder lifts were 4 inches and 1.5 inches thick; the surface lift was 1.5 inches thick. The first binder lift was designed to be 3 inches, but due to the construction problems discussed later in the “Challenges” section, the lift thickness was increased to 4 inches. Once the first binder lift was placed on the first lane rubblized, traffic was moved onto the first binder lift and the other lane was rubblized and paved with the first lift of binder. The road was turned over to two-lane two-direction traffic at the end of each day once the first binder lift of the bituminous concrete overlay was completed on both lanes.

OGBC with a 4-Inch Bituminous Concrete Overlay

After underdrains were placed, the centerline was milled 2 inches deep and two feet wide, and then filled with leveling binder. Cracks were also filled with leveling binder. Placement of the 3-inch OGBC followed this preparation. The base course mix design was based on an open-graded, clean coarse aggregate (ASTM 57 gradation) with an asphalt content of 2.7 percent. Mix temperature was 240° F and placement temperature was 225° F to limit drain-down of the asphalt. Figure 11 shows the OGBC.

Both a vibratory and a static roller were used for compaction of the base course. Sand was applied to the base course to prevent tracking. About 2 lane-miles of OGBC and one 2.5-inch binder lift were placed per day then opened to traffic. With the 1.5-inch surface lift, the total bituminous concrete overlay thickness was 4 inches, or 7 inches including the OGBC.

A pilot car was used to guide traffic through this section so traffic and turning movements would not adversely affect the OGBC.

Minimal PCC Patching with a Thick Bituminous Concrete Overlay

After underdrains were placed, the centerline was milled 2 inches deep and two feet wide then filled with leveling binder. Cracks were also filled with leveling binder. PCC patching was conducted on 3.9 percent of the pavement area. Three lifts of bituminous concrete were placed for a total overlay thickness of 4.0 inches. The lifts consisted of an average of 1.0 inch level binder, 1.5 inches binder, and 1.5 inches surface. About 2 lane-miles of one binder lift were placed per day then opened to traffic.

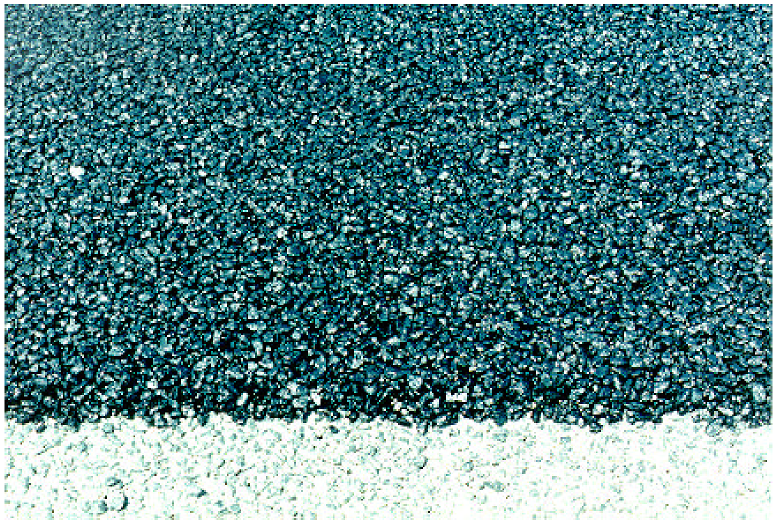

Figure 11. OGBC (IL 38 1994).

Standard PCC Patching with a Standard Bituminous Concrete Overlay (Control)

After underdrains were installed, PCC patching was conducted on 3.5 percent of the control section area, followed by placement of a 2.5-inch bituminous concrete overlay. The overlay consisted of one 1-inch lift of level binder and one 1.5-inch lift of surface.

<u>Challenges</u>

Challenges were encountered only on the rubblize and overlay section. Materials testing prior to construction indicated a soft subbase with an Immediate Bearing Value (IBV) of 3. The IBV is obtained using the Dynamic Cone Penetrometer (DCP) and is taken to be equivalent to the field California Bearing Ratio (CBR) (ASTM D 4429).

This soft subbase caused large pieces of concrete to remain at the joints and cracks (see Figure 12). Several pieces larger than 12 inches on the surface that moved under rolling were removed and replaced with an open-graded, clean coarse aggregate (ASTM 57 gradation). The rubblizing machine's breaking frequency was increased, the travel speed was slowed, and the distance between subsequent passes of the PB-4 was narrowed to improve the breaking effectiveness.

The soft subgrade caused additional problems once paving began. Traffic was allowed on the first 3-inch lift of binder. Severe rutting problems occurred when vehicles traveled on this lift. In one location, the pavement failed and had to be excavated and replaced with a coarse aggregate having a 2.5-inch top size. As a result of this early rutting, the first lift of binder was increased from 3 inches to an average of 4 inches.

Figure 12. Large Rubblized Pieces (IL 38 1994).

Performance

Performance has been monitored since construction. Items examined include CRS values and visual distress surveys, IRI, rutting, and FWD testing.

CRS Values and Visual Distress Surveys

The pavement has been surveyed for deterioration most years since construction. The rubblization section was rated for CRS separately from the other sections because it is in Lee County. The other three sections, in Ogle County, were rated together.

Rubblization with a 7-Inch Bituminous Concrete Overlay

The CRS value of the rubblized section was 7.2 in 1999, considered good. The distresses for the section that was rubblized and overlaid with bituminous concrete are summarized in Table 6. Figure 13 shows the pavement, with a transverse crack, in 1996.

Table 6. Summary of Visual Distress Surveys on Rubblize and Overlay (IL 38 1994).

			Age of Pavement (Years)				
Distress	Severity	Units	0	1	2	3	6
Block Cracking	Low	Feet/Lane Mile	0	0	0	0	341
	Medium	Feet/Lane Mile	0	0	0	0	0
	High	Feet/Lane Mile	0	0	0	0	0
Longitudinal Cracking	Low	Feet/Lane Mile	0	0	0	10	48
	Medium	Feet/Lane Mile	0	0	0	0	0
	High	Feet/Lane Mile	0	0	0	0	0
Transverse Cracking	Low	Number/Lane Mile	0	<1*	2	3	13
	Medium	Number/Lane Mile	0	0	0	0	0
	High	Number/Lane Mile	0	0	0	0	0

* Over a culvert.

Figure 13. Rubblize and Overlay in 1996 (IL 38 1994).

OGBC with a 4-Inch Bituminous Concrete Overlay

The CRS value of the OGBC section was 6.7 in 1999, considered good. The distresses for the section that was constructed with an OGBC and overlaid with bituminous concrete are summarized in Table 7. Figure 14 shows the pavement, with two sealed transverse cracks, in 1997.

Table 7. Summary of Visual Distress Surveys on OGBC and Overlay (IL 38 1994).

			Age of Pavement (Years)				
Distress	Severity	Units	0	1	2	3	6
Block Cracking	Low	Feet/Lane Mile	0	0	0	0	247
	Medium	Feet/Lane Mile	0	0	0	0	0
	High	Feet/Lane Mile	0	0	0	0	0
Longitudinal Cracking	Low	Feet/Lane Mile	0	0	0	0	8
	Medium	Feet/Lane Mile	0	0	0	0	0
	High	Feet/Lane Mile	0	0	0	0	0
Transverse Cracking	Low	Number/Lane Mile	0	10	53	82	4
	Medium	Number/Lane Mile	0	0	27	35	0
	High	Number/Lane Mile	0	0	0	0	0

Minimal PCC Patching with a Thick Bituminous Concrete Overlay

The CRS value of the thick overlay section was 6.7 in 1999, considered good. The distresses for the section that had minimum patching and a thick bituminous concrete overlay are summarized in Table 8.

Figure 14. OGBC and Overlay in 1997 (IL 38 1994).

Table 8. Summary of Visual Distress Surveys on Thick Overlay (IL 38 1994).

			Age of Pavement (Years)				
Distress	Severity	Units	0	1	2	3	6
Block Cracking	Low	Feet/Lane Mile	0	0	0	0	137
	Medium	Feet/Lane Mile	0	0	0	0	0
	High	Feet/Lane Mile	0	0	0	0	0
Longitudinal Cracking	Low	Feet/Lane Mile	0	0	0	0	15
	Medium	Feet/Lane Mile	0	0	0	0	0
	High	Feet/Lane Mile	0	0	0	0	0
Transverse Cracking	Low	Number/Lane Mile	0	90	95	69	3
	Medium	Number/Lane Mile	0	0	0	32	0
	High	Number/Lane Mile	0	0	0	0	0

Standard PCC Patching with a Standard Bituminous Concrete Overlay (Control)

The CRS of the control section was 6.6 in 1999, considered good. The distresses for the control section are summarized in Table 9. The control section could not be surveyed in 2000 due to maintenance work being conducted on the section. Figure 15 shows the pavement, with a transverse crack that has been sealed in the far lane, in 1997. The remainder of the crack was sealed after the photo was taken.

IRI and Rutting

The IRI and rutting data have been collected most years since construction. The IRI and rutting data for the three test sections and the control section are contained in Table 10. Rutting values are representative of new pavement. Roughness, while higher than new pavements, is still acceptable.

Table 9. Summary of Visual Distress Surveys on Control Section (IL 38 1994).

Distress	Severity	Units	Age of Pavement (Years) 0	1	2	3
Longitudinal Cracking	Low	Feet/Lane Mile	0	0	0	0
	Medium	Feet/Lane Mile	0	0	0	0
	High	Feet/Lane Mile	0	0	0	0
Transverse Cracking	Low	Number/Lane Mile	0	21	0	0
	Medium	Number/Lane Mile	0	53	116	125
	High	Number/Lane Mile	0	0	11	11

Figure 15. Control Section in 1997 (IL 38 1994).

Table 10. IRI and Rutting Data (IL 38 1994).

	Rubblize & Overlay		OGBC & Overlay		Thick Overlay		Control	
Year	IRI (in./mi.)	Rut (in.)	IRI (in./mi.)	Rut (in.)	IRI (in./mi.)	Rut (in.)	IRI (in./mi.)	Rut (in.)
1995	86	0.03	75	0.04	73	0.02	84	0.03
1996	89	0.04	80	0.05	76	0.02	85	0.02
1997	92	0.06	92	0.04	90	0.04	92	0.04
1999	113	0.05	107	0.04	107	0.04	107	0.04

<u>FWD</u>

FWD data have been collected most years since the construction of the pavement. The average deflection data are summarized in Table 11. The deflections, area, and E_{RI} remain essentially unchanged since construction in 1994.

Table 11. FWD Data for All Sections (IL 38 1994).

Year	Section	Temp. (°F)	Deflection (mils)	Area (in.)	E_{RI} (ksi)
1994	Rubb.	57	5.9	23.8	11.9
1994	OGBC	53	3.5	27.5	12.8
1994	Thick OL	53	3.3	30.1	12.1
1994	Control	53	3.8	30.1	10.6
1996	Rubb.	90	8.6	22.8	8.6
1996	OGBC	90	6.0	26.4	7.2
1996	Thick OL	90	5.0	30.3	6.8
1996	Control	90	6.0	30.5	4.9
1997	Rubb.	67	6.9	23.4	13.0
1997	OGBC	67	5.2	28.0	7.9
1997	Thick OL	67	4.5	30.6	7.9
1997	Control	67	5.2	31.1	6.0
1998	Rubb.	109	8.0	20.8	13.5
1998	OGBC	109	6.0	24.1	8.5
1998	Thick OL	109	4.9	29.1	7.9
1998	Control	109	5.6	29.6	6.3
1999	Rubb.	48	5.9	25.0	13.6
1999	OGBC	48	5.1	28.9	8.2
1999	Thick OL	48	4.5	30.7	8.2
1999	Control	48	5.7	29.8	6.7

Project Summary

Two major observations were made of the constructability of this project. The subgrade had an IBV of 3, and the PB-4 had difficulty getting adequate breaking of the pavement. The first binder lift, at 3 inches, was insufficient to protect the rubblized pavement from the rigors of traffic. Once the lift thickness was increased to 4 inches, the traffic no longer damaged the rubblized layer.

From a performance standpoint, although the control section had the lowest percentage recommended patching, three years after construction it had the highest amount and worst severity transverse cracking. The amount of reflective cracking on the rubblized section at six years was less than the amount of reflective cracking on the control section at three years. Roughness and rutting are acceptable on all four sections after six years of service.

INTERSTATE 55 FRONTAGE ROAD CONSTRUCTED 1994

A non-interstate route was selected for Experimental Feature IL 94-02, PCC rubblization and bituminous concrete overlay, in 1994. The entire project was constructed using the rubblization method with a bituminous concrete overlay under Contract #92685.

Project Background

The selected route's location, cross section, traffic, preconstruction condition, and test section description are contained in the following sections.

Location, Cross Section, and Traffic

The project is located on the west Interstate 55 Frontage Road in Logan County. It begins at the interchange north of Lincoln where Business 55 enters I-55 and ends at Lawndale, about 1.9 miles northeast (see Figure 16). The existing pavement was constructed as a 10-inch JRC pavement with welded wire fabric and 100-foot joint spacing. The pavement had two 12-foot lanes and aggregate shoulders. In 1991, the section had an ADT of 1,650 vehicles with 10 percent trucks.

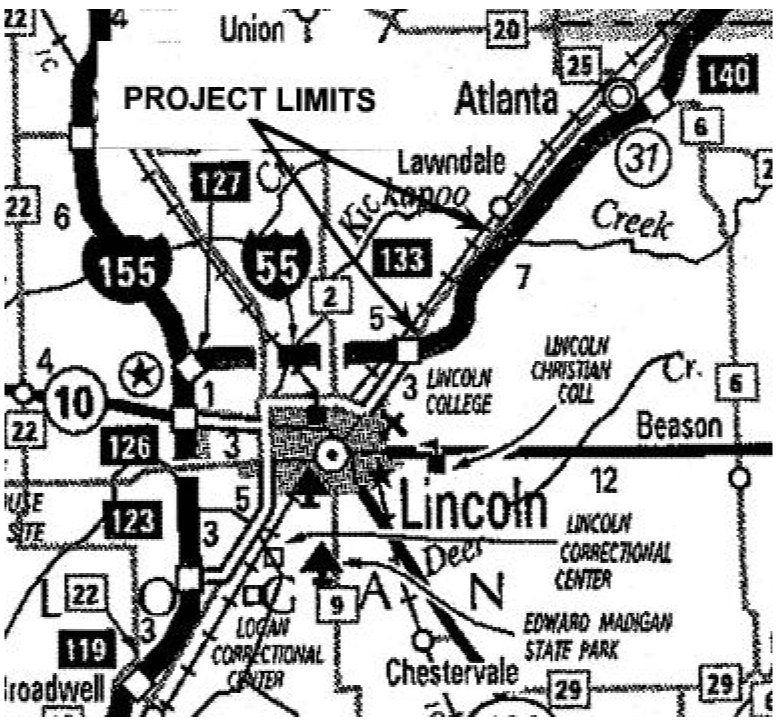

Figure 16. Location of I-55 Frontage Road
Project Constructed in 1994.

Preconstruction Condition

The CRS value and distresses were obtained to determine the existing condition of the pavement. The CRS value of this section was 4.3, poor condition, in 1990. Extensive D-cracking was present on this pavement. The centerline joint was highly distressed. PCC patching at the joints had been performed by the Department in previous years. Severely distressed transverse cracks existed every 5 to 15 feet. Patching, if performed, could have totaled up to 18 percent of the pavement. Figure 17 shows the preconstruction condition of this pavement.

Figure 17. Preconstruction Condition (I-55 FR 1994).

Test Section Description

The entire contract consisted of one test section. The existing JRC pavement was rubblized and used as a subbase. A 5-inch bituminous concrete overlay, the minimum thickness thought feasible, was constructed on top of the rubblized pavement. Underdrains were added to the pavement cross section.

Construction

The project was constructed in August 1994. The road was closed to the traveling public while under construction. The equipment used, construction sequence, and challenges encountered are discussed in the next sections.

Equipment

The machine used to rubblize the existing JRC pavement was a PB-4 resonant breaker, operated by International Resonant Breaking, Inc.

Sequence

Pipe underdrains and underdrain outlet pipes were installed at the edge of pavement at the start of construction. Rubblizing of the existing concrete pavement then proceeded. About 0.25 two-lane mile was rubblized per day at a pace comparable to a slow walk. The operator needed to make about 20 passes to completely rubblize each traffic lane. Each lane was rubblized in the direction of traffic. Figure 18 shows the rubblizing process.

Figure 18. Rubblizing Process (I-55 FR 1994).

The rubblized pavement was compacted using one pass by a vibratory roller, one pass by a pneumatic roller, then two passes by a vibratory roller. The bituminous concrete overlay was constructed directly on top of the rubblized concrete pavement. The bituminous concrete overlay consisted of two 1.75-inch lifts of binder course and one 1.5-inch lift of surface course.

Challenges

No challenges were encountered during the rubblizing process. When the initial lift of binder was placed, the floating-beam reference ski was riding on the rubblized concrete. This caused difficulties in achieving a uniform thickness. The centerline of the rubblized concrete was recompacted, alleviating this problem. Achieving density was another challenge on the first lift of binder. The binder course was placed 1.5 inches thick the first day. Pavement core results indicated densities that ranged from 84 to 90 percent. The binder course thickness was increased to 1.75 inches after the first day and the required density of 93 percent was obtained thereafter.

Performance

Performance has been monitored since construction. Items examined include CRS values and visual distress surveys, IRI, rutting, and FWD testing.

CRS Values and Visual Distress Surveys

The CRS value in 1999 was 6.8 in one direction and 7.5 in the other direction. Both values are considered good. The pavement has been surveyed for deterioration most years since construction. The distresses are summarized in Table 12. Figure 19 shows the pavement in 1997.

Table 12. Summary of Visual Distress Surveys (I-55 FR 1994).

			Age of Pavement (Years)				
Distress	Severity	Units	0	1	2	3	6
Block Cracking	Low	Feet/Lane-Mile	0	0	31	561	2164
	Medium	Feet/Lane-Mile	0	0	0	0	0
	High	Feet/Lane-Mile	0	0	0	0	0
Longitudinal Cracking	Low	Feet/Lane-Mile	0	0	443	430	1052
	Medium	Feet/Lane-Mile	0	0	52	52	0
	High	Feet/Lane-Mile	0	0	0	0	0
Transverse Cracking	Low	Number/Lane-Mile	0	2	58	64	108
	Medium	Number/Lane-Mile	0	0	1	11	0
	High	Number/Lane-Mile	0	0	0	0	0

Figure 19. Rubblized/Overlaid Pavement in 1997 (I-55 FR 1994).

IRI and Rutting

The IRI and rutting data are collected every odd-numbered year. In 1999, the year for which the most recent data is available, the IRI was 100 inches per mile. The rut depth averaged 0.05 inches in the wheel paths. Both values are acceptable for a five-year-old pavement surface.

FWD

FWD data have been collected most years since the construction of the pavement. The results are summarized in Table 13. The deflections have remained relatively constant, between 11 and 14 mils. These deflections are slightly higher than on a full-depth bituminous concrete pavement which has been newly constructed from the subgrade to the surface. From 1994 to 1998, the E_{RI} increased, reflecting the “seating” and densification of the rubblized layer under traffic.

Table 13. Falling Weight Deflectometer Data (I-55 FR 1994).

Year	Temp. (°F)	Deflection (mils)	Area (in.)	E_{RI} (ksi)
1994	63	13.7	22.9	4.8
1996	48	11.6	23.5	5.7
1997	80	13.1	22.2	8.6
1998	68	11.0	22.5	10.1
1999	46	11.8	22.8	9.3

Project Summary

Rubblizing the concrete pavement went well. Achieving density on the first lift of bituminous concrete was difficult until the lift thickness was increased to 1.75 inches.

No deterioration occurred until the bituminous concrete overlay was two years old. In the third year, transverse cracking, block cracking, and longitudinal cracking appeared. The distresses were low to medium severity and did not progress in severity through the end of the sixth year. All distresses increased in quantity although not in severity in the sixth year. The extent of distress and the magnitude of deflections indicate the thickness was insufficient.

INTERSTATE 57 CONSTRUCTED 1996

An interstate route was selected for Experimental Feature IL96-05, PCC rubblization and a bituminous concrete overlay, in 1996. The site was the northbound lanes of I-57 south of Effingham, Illinois. The project was constructed under contract #94389 and included a patch and overlay section to serve as a control. The experimental feature included rubblizing with two overlay thicknesses as well as a control section of 5 inches bituminous concrete overlay with PCC patching. An additional test section included PCC patching and a 6-inch bituminous concrete overlay of the existing pavement.

Project Background

The selected route's location, cross section, traffic, preconstruction condition, and test section description are contained in the following sections.

Location, Cross Section, and Traffic

The project is located in Effingham County. The section begins at the Edgewood exit at milepost 145 and continues north 4.3 miles (see Figure 20). The existing cross section consisted of an 8-inch CRC pavement over a 4-inch bituminous aggregate mixture (BAM) subbase that had been previously overlaid. In 1995, the section had an ADT of 13,600 vehicles with 30 percent trucks.

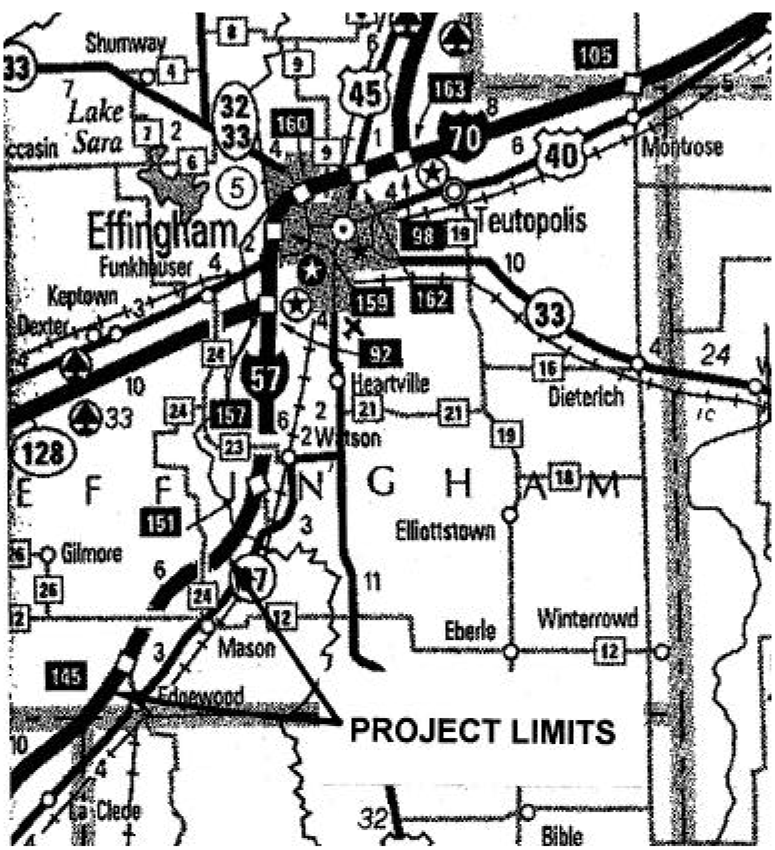

Figure 20. Location of I-57 Project Constructed in 1996.

Preconstruction Condition

The CRS value was obtained to determine the existing condition of the pavement. The CRS value of the section was 5.0 in 1995. A 5-inch bituminous concrete overlay with 8 to 12 percent patching was originally proposed for this section. Ground Penetrating Radar determined the section would require about 12 percent patching using Department guidelines.

Deflection testing was performed to determine the areas of poor support. Cores and soil samples were taken to help evaluate possible problems that might be encountered during construction. Coring indicated that the BAM subbase was only partially intact due to asphalt stripping. Concrete cores taken exhibited some planar fracturing, indicating the presence of D-cracking. In situ soil strength data were gathered to determine if a minimum level of soil support for the rubblizing process existed. IBVs were found to range from 3 to 5, the minimum level needed to support rubblizing operations, as identified on the Illinois Route 38 project.

Test Section Description

The majority of the project consisted of an 8-inch bituminous concrete overlay over the rubblized pavement. Two additional test sections and one control section were also constructed. The sections are as follows:

- Station 4274+05 to 4286+95: 5-inch bituminous concrete overlay of the existing pavement.
- Station 4330+35 to 4473+05 and Station 4489+20 to 4496+50: 8-inch bituminous concrete overlay of the rubblized pavement.
- Station 4473+05 to 4478+05: 6-inch bituminous concrete overlay of the existing pavement.
- Station 4485+00 to 4489+20: 6-inch bituminous concrete overlay of the rubblized pavement.

A standard bituminous concrete overlay of an interstate pavement in Illinois includes patching and 3.25 inches bituminous concrete. The control section of this project was a thick overlay.

All previous overlays were milled from all sections. Pavement within 300 feet of overhead structures was not rubblized and is not included in any of the test or control sections. The Edgewood intersection is located between sta. 4286+95 and 4330+35, and the mainline pavement in that area is not included in the construction or performance monitoring.

Construction

The project was constructed in 1996. The operation proceeded in one lane while the public continued traveling in the adjacent lane. The equipment used, construction sequence, and challenges encountered are discussed in the next sections.

Equipment

The MHB and Z-grid roller were used on this project. This was the first time this equipment combination was used in Illinois. The Z-grid was bolted around the roller drum longitudinally (see Figure 21). At optimum performance, the rubblizing progressed at about 500 feet per hour.

Figure 21. Z-Grid Roller, Longitudinally Attached (I-57 1996).

Sequence

The driving lane was rehabilitated first, as shown in Figure 22. Underdrains were installed, the existing bituminous concrete pavement was removed, the rubblization operation was completed, and the binder lifts of the overlay were placed. On the rubblization with 8-inch overlay section, three binder lifts for a total of 6.5 inches were placed. Because a 12.5-foot wide milling machine was used, all operations were underway simultaneously. Once all binder layers had been constructed, traffic was switched to the driving lane and the passing lane was rehabilitated. The 1.5-inch surface course was then placed on the entire project.

Challenges

On the first day of paving, a rubber-tired paver was used. The rubblized material moved around under the small tires in the front, as shown in Figure 23. On the second day of paving, a tracked paver was used, significantly reducing problems with the paving operation.

Accomplishing the project under traffic did not impair traffic flow any more than a standard paving operation while keeping one lane open to traffic. Bituminous milling, rubblizing, rolling, and paving were often done simultaneously on this project.

Figure 22. Driving Lane Rubblizing (I-57 1996).

Figure 23. Rubblized Material Moving Under Bogey Tires of Paver (I-57 1996).

Performance

Performance has been monitored since construction. Items examined include CRS values and visual distress surveys, IRI, rutting, and FWD testing.

<u>CRS Values and Visual Distress Surveys</u>

The CRS value in 2000 for all sections was 7.8, considered excellent. Distress surveys were performed in 1998 and 2000. In 2000, the 5-inch overlay control section exhibited 5 low-severity transverse cracks, or 10.2 cracks per lane-mile, and 4 feet of low-severity longitudinal cracking, or 8.2 feet per lane-mile. The rubblized and 8-inch overlay section had 2 low-severity transverse cracks, or 0.4 cracks per lane-mile. The other two sections did not show any distresses. Figure 24 shows one transverse crack in the rubblized and 8-inch overlay section in 1998.

Figure 24. Rubblize and 8" Overlay in 1998 (I-57 1996).

IRI and Rutting

The IRI and rutting data have been collected every year since construction. The IRI and rutting data for all sections are contained in Table 14. The IRI is comparable to new pavement on all sections. Rutting is higher on the rubblized sections, but is acceptable.

Table 14. IRI and Rutting Data (I-57 1996).

	5" Overlay		6" Overlay		Rubblize & 6" Overlay		Rubblize & 8" Overlay	
Year	IRI (in./mi.)	Rut (in.)	IRI (in./mi.)	Rut (in.)	IRI (in./mi.)	Rut (in.)	IRI (in./mi.)	Rut (in.)
1997	56	0.01	51	0.03	68	0.07	61	0.05
1998	82	0.04	52	0.06	83	0.09	67	0.08
1999	61	0.06	49	0.07	75	0.12	62	0.10
2000	84	0.08	52	0.10	94	0.14	68	0.12

FWD

FWD data have been collected most years since the construction of the pavement. The average deflection data are summarized in Table 15. The data appear improved in 1999 due to the low temperature at the time of testing.

Table 15. FWD Data for All Sections (I-57 1996).

Year	Section	Temp. (°F)	Deflection (mils)	Area (in.)	E_{RI} (ksi)
1996	5" OL	–	–	–	–
1996	6" OL	–	–	–	–
1996	Rubb. 6"	110	14.3	23.9	6.7
1996	Rubb. 8"	105	8.6	26.1	9.2
1996	5" OL	–	–	–	–
1996	6" OL	–	–	–	–
1997	Rubb. 6"	75	11.5	24.8	7.9
1997	Rubb. 8"	75	7.8	26.0	10.1
1998	5" OL	86	5.4	28.5	11.4
1998	6" OL	86	4.4	27.2	13.6
1998	Rubb. 6"	86	17.0	23.2	5.1
1998	Rubb. 8"	86	10.1	24.7	8.8
1999	5" OL	–	–	–	–
1999	6" OL	46	2.9	30.1	15.9
1999	Rubb. 6"	46	9.1	24.4	10.6
1999	Rubb. 8"	46	5.8	27.1	12.3

Project Summary

The project construction went well using the MHB and Z-grid roller. Traffic was impacted no more than on a standard patch and overlay project. The rubber-tired paver had some difficulty operating directly on the rubblized layer. Once a tracked paver was substituted, paving progressed quickly.

Performance to date on all sections has been excellent. There is more cracking on the control section. Roughness, rutting, and structural capacity as measured by the FWD, are all acceptable.

INTERSTATE 70 CONSTRUCTED 1997

Three interstate routes were selected for Experimental Feature IL97-03, PCC rubblization and a bituminous concrete overlay. Two projects were constructed in 1997. The first site was the westbound lanes of I-70 east of Greenup, Illinois. The project was constructed under contract #90675 and included a patch and 5.5-inch overlay section to serve as a control. The experimental feature included rubblizing with overlay thicknesses of 9 inches, 10 inches, and 11 inches, in addition to the control section.

Project Background

The selected route's location, cross section, traffic, preconstruction condition, and test section description are contained in the following sections.

<u>Location, Cross Section, and Traffic</u>

The project is located in Cumberland County, between mileposts 119.5 and 123.4, in the westbound lanes (see Figure 25). The existing cross section consisted of an 8-inch CRC pavement over a 4-inch BAM subbase that had been previously overlaid. In 1997, the section had an ADT of 17,500 vehicles with 40 percent trucks.

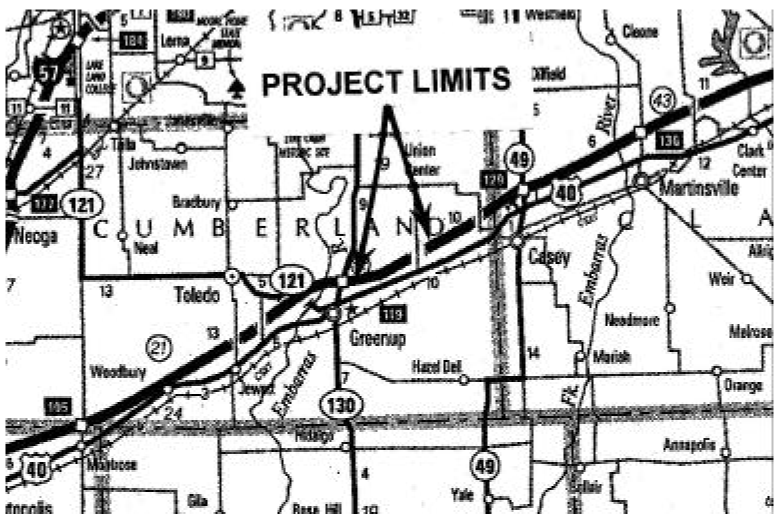

Figure 25. Location of I-70 Project Constructed in 1997.

<u>Preconstruction Condition</u>

The CRS value was obtained to determine the existing condition of the pavement. The CRS value of the section was 5.7, fair condition, in 1996. The existing concrete pavement had incorporated D-cracking aggregates. Two overlays had been previously placed. The preconstruction condition is shown in Figure 26.

Deflection testing was performed to determine the areas of poor support. Cores and soil samples were taken to help evaluate possible problems that might be encountered during construction. Coring indicated that the BAM subbase was only partially intact. In situ soil strength data were gathered to determine if a minimum level of soil support for the rubblizing process existed. IBVs were found to range from 3 to 5, the minimum level needed to support rubblizing operations.

Figure 26. Preconstruction Condition (I-70 1997).

Test Section Description

The majority of the project was constructed with a 10-inch bituminous concrete overlay over the rubblized pavement. Two additional rubblized sections and one control section were also constructed. The sections are as follows:

- Station 206+367.4 to 202+158: 10-inch bituminous concrete overlay of the rubblized pavement.
- Station 202+158 to 201+825.5: 11-inch bituminous concrete overlay of the rubblized pavement.
- Station 201+825.5 to 201+519.5: 9-inch bituminous concrete overlay of the rubblized pavement.
- Station 201+519.5 to 201+198.5: 5.5-inch bituminous concrete overlay of the existing pavement.

A standard bituminous concrete overlay of an interstate pavement in Illinois includes patching and 3.25 inches bituminous concrete. The control section of this project was a thick overlay.

All previous overlays were milled from all sections. Pavement within 300 feet of overhead structures was not rubblized and is not included in any of the test or control sections.

Construction

The project was constructed in July 1997. The operation proceeded in one lane while the public continued traveling in the adjacent lane. The equipment used, construction sequence, and challenges encountered are discussed in the next sections.

Equipment

The MHB and Z-grid roller were used on this project. The Z-grid was bolted transversely to the roller drum, as shown in the section titled “Rubblizing Equipment”. At optimum performance, the rubblizing progressed at about 500 feet per hour.

Sequence

The driving lane was rehabilitated first. The existing bituminous concrete overlay was milled and the existing concrete pavement was rubblized. The binder lifts were placed. Binder lift thicknesses were 7.5 inches, 8.5 inches, and 9.5 inches for the rubblized sections with 9-inch, 10-inch, and 11-inch overlays, respectively. Figure 27 shows the first lift of binder on the rubblized pavement. Traffic was then switched to the driving lane so the passing lane could be rehabilitated. Once binder was placed on both lanes and shoulders, the 1.5-inch surface was constructed.

Figure 27. Driving Lane Rubblized and One Lift Binder (I-70 1997).

Challenges

No challenges were encountered with the rubblizing procedure. However, the milling operation varied between 12 and 12.5 feet. To have enough clearance for the rubblizing operation, particularly in an inlay situation, 12.5 to 13 feet is ideal.

Performance

Performance has been monitored since construction. Items examined include CRS values and visual distress surveys, IRI, rutting, and FWD testing.

CRS Values and Visual Distress Surveys

The CRS value in 2000 for all sections was 8.3, considered excellent. Distress surveys were performed in 1998 and 2000. The 1998 survey showed water and a calcium material on the pavement in isolated locations. This appeared to be caused by a plugged underdrain outlet, and subsided after the drain was opened. In 2000, the rubblized section with a 10-inch overlay had 4 low-severity transverse cracks, or 0.8 cracks per lane-mile. The remaining sections did not show any distresses.

IRI and Rutting

The IRI and rutting data have been collected every year since construction. The IRI and rutting data for all sections are contained in Table 16. Both the IRI and rutting are comparable on all sections. The IRI is similar to new pavements. Rutting is higher than anticipated, but is still acceptable.

Table 16. IRI and Rutting Data (I-70 1997).

	5.5" Overlay		Rubblize & 9" Overlay		Rubblize & 10" Overlay		Rubblize & 11" Overlay	
Year	IRI (in./mi.)	Rut (in.)	IRI (in./mi.)	Rut (in.)	IRI (in./mi.)	Rut (in.)	IRI (in./mi.)	Rut (in.)
1998	78	0.09	59	0.05	68	0.06	74	0.03
1999	48	0.13	47	0.12	65	0.13	67	0.13
2000	50	0.17	51	0.18	64	0.16	72	0.16

FWD

FWD data have been collected most years since the construction of the pavement. The average deflection data are summarized in Table 17. The data appear improved in 1999 due to the low temperature at the time of testing.

Table 17. FWD Data for All Sections (I-70 1997).

Year	Section	Temp. (°F)	Deflection (mils)	Area (in.)	E_{RI} (ksi)
1997	Control	70	5.4	25.7	13.0
1997	Rubb. 9”	70	10.7	19.8	13.7
1997	Rubb. 10"	70	11.1	23.1	9.1
1997	Rubb. 11"	70	8.5	21.0	14.1
1998	Control	93	5.8	25.9	11.7
1998	Rubb. 9”	93	6.8	21.6	14.8
1998	Rubb. 10"	93	11.2	23.7	8.3
1998	Rubb. 11"	93	8.5	22.0	13.1
1999	Control	49	4.4	26.5	12.5
1999	Rubb. 9”	49	5.2	22.6	15.5
1999	Rubb. 10"	49	5.6	25.7	11.2
1999	Rubb. 11"	49	4.3	23.5	16.1

Project Summary

Construction of the project went well. The project was an inlay, and it was discovered that the milling machine needed to mill 12.5 to 13 feet wide to provide enough clearance for the MHB. Performance has been acceptable to date. There is very little cracking, and roughness is very low. Rutting is acceptable, and structural capacity, as measured with the FWD, is very good.

INTERSTATE 57 CONSTRUCTED 1997

The second interstate route selected for Experimental Feature IL97-03, PCC rubblization and a bituminous concrete overlay, was the southbound lanes of I-57 near Anna. The project was constructed in 1997 under contract #98387. The experimental feature included rubblizing with a 9-inch overlay. No control section or alternate overlay thickness sections were included. In one 500-foot location, the existing concrete was rubblized to 9- to 12-inch pieces, instead of pieces less than 9 inches.

Project Background

The selected route's location, cross section, traffic, preconstruction condition, and test section description are contained in the following sections.

Location, Cross Section, and Traffic

The project is located in Union County, between mileposts 29.6 and 32.1 in the southbound lanes (see Figure 28). The existing cross section consisted of a 10-inch JRC pavement over a 6-inch granular subbase. In 1997, the section had an ADT of 10,400 vehicles with 39 percent trucks.

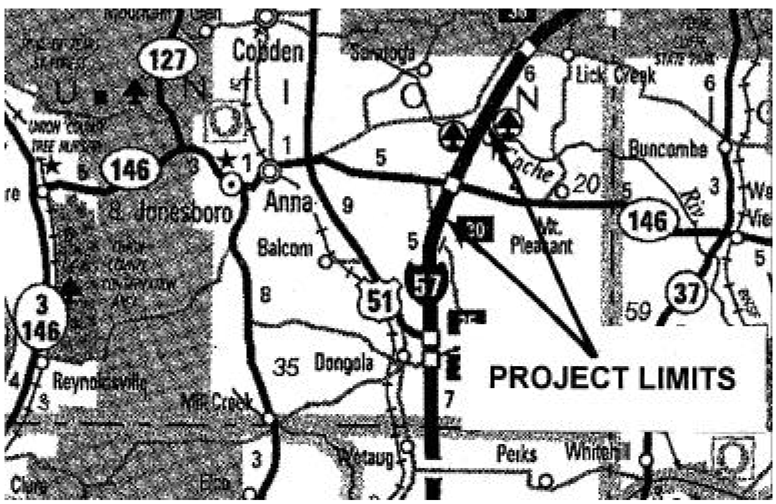

Figure 28. Location of I-57 Project Constructed in 1997.

Preconstruction Condition

The CRS value was obtained to determine the existing condition of the pavement. The CRS value of the section was 5.0, fair condition, in 1996. The joints in the pavement were severely deteriorated. If a standard PCC patch and 3.25-inch bituminous concrete overlay project had been performed, approximately 14.5 percent patching would have been needed. Figure 29 shows the preconstruction condition of the pavement.

Cores and soil samples were taken to help evaluate possible problems that might be encountered during construction. In situ soil strength was gathered to determine if a minimum level of soil support for the rubblizing process existed. IBVs were found to be about 5, an acceptable level to support rubblizing operations.

Figure 29. Preconstruction Condition (I-57 1997).

<u>Test Section Description</u>

The entire contract consisted of one test section. The existing JRC pavement was rubblized and used as a subbase. A 9-inch bituminous concrete overlay was constructed on top of the rubblized pavement from station 47+570 to 51+671, with the exception of a bridge omission.

A 500-foot long area in the driving lane, from station 48+687 to 48+837, was rubblized to a greater size than the standard rubblizing procedure. The intent of this section was to determine if it is more cost beneficial to break to a larger size, which is faster then breaking to the smaller size. The larger breaking size may introduce reflective cracking, the elimination of which is one of the primary reasons rubblizing is performed.

Construction

The project was constructed in September and October 1997. The operation proceeded in one lane while the public continued traveling in the adjacent lane. The equipment used, construction sequence, and challenges encountered are discussed in the next sections.

<u>Equipment</u>

The MHB and Z-grid roller were used on this project. At optimum performance, the rubblizing progressed at about 500 feet per hour.

<u>Sequence</u>

The passing lane was rehabilitated first. The existing concrete pavement was rubblized and the two binder lifts were placed. The first and second binder lifts were designed to be 4.5 and 2.5 inches thick, respectively. Traffic was then switched to the passing lane so the driving lane could be rehabilitated (see Figure 30). Once binder was placed on both lanes and shoulders, the 2-inch surface was constructed.

Figure 30. Passing Lane Binder, Driving Lane Rubblizing Begun (I-57 1997).

Challenges

The largest challenge was encountered at the rest area and intersection ramps. The mainline pavement was 11 feet 4 inches wide. The rubblizing equipment was set to rubblize 12 feet, which resulted in a small portion of the bituminous concrete shoulder being rubblized with the pavement. At the rest area exit ramp, an attempt was made to rubblize only the mainline pavement. Because of the configuration of the MHB, two passes of the MHB needed to be made. To avoid the need for two passes, the decision was made to leave the equipment at 12 feet and rubblize a small portion of the remaining ramps.

Performance

Performance has been monitored since construction. Items examined include CRS values and visual distress surveys, IRI, rutting, and FWD testing.

CRS Values and Visual Distress Surveys

The CRS value on 2000 was 8.8, considered excellent. Distress surveys were performed in 1998 and 2000. In both years, low-severity asphalt bleeding was noted intermittently between sta. 50+330 and 50+530. In 2000, there were 2 transverse cracks in the rubblized section. One of the cracks was at the change from standard rubblization size to the larger rubblization size.

IRI and Rutting

The IRI and rutting data have been collected every year since construction. The IRI and rutting data for all sections are contained in Table 18. The IRI is similar to new pavements.

Table 18. IRI and Rutting Data (I-57 1997).

Year	Rubblize & 9" Overlay IRI (in./mi.)	Rubblize & 9" Overlay Rut (in.)
1998	64	0.03
1999	81	0.28
2000	88	0.31

Rutting was noted within a year of the construction. A forensic investigation indicated that the rutting was not attributable to the rubblizing process. An upper lift of the bituminous concrete overlay was unstable. A memo discussing the materials testing and conclusions can be found in Appendix A.

FWD

FWD data have been collected most years since the construction of the pavement. The deflection data are summarized in Table 19. The average deflection data are acceptable for both sections. The larger rubblization pieces show a lower average deflection, and slightly higher average area and E_{RI}. The data appear improved in 1999 due to the low temperature at the time of testing.

Table 19. FWD Data (I-57 1997).

Year	Section	Temp. (°F)	Deflection (mils)	Area (in.)	E_{RI} (ksi)
1997	Standard	47	4.6	26.4	14.3
1997	Large	–	–	–	–
1998	Standard	98	10.1	22.3	11.6
1998	Large	98	6.3	22.8	13.9
1999	Standard	48	4.4	25.9	15.7
1999	Large	48	3.2	27.0	16.9

Project Summary

During the construction phase of the project, the only challenge regarded rubblizing near the ramps. It was more feasible to rubblize 6 to 8 inches of the ramps, than to set the rubblizing equipment narrow and make two passes.

Performance has been acceptable to date, with the exception of the amount of rutting. The rutting was determined to be unrelated to the rubblized layer. The area with larger rubblized pieces has lower deflections, but it is too soon to tell if there will be a long-term impact on reflective cracking.

INTERSTATE 74 CONSTRUCTED 1999

The third interstate route selected for Experimental Feature IL97-03, PCC rubblization and a bituminous concrete overlay, was the westbound lanes of I-74 north of Woodhull, Illinois. The project was constructed in 1999 under contract #64065. The experimental feature included rubblizing with an 11-inch overlay and a control section consisting of a 5.5-inch overlay of the undisturbed concrete pavement.

Project Background

The selected route's location, cross section, traffic, preconstruction condition, and test section description are contained in the following sections.

<u>Location, Cross Section, and Traffic</u>

The project is located in Henry County. The section begins just west of the Woodhull interchange, at approximately milepost 32 and proceeds west to approximately milepost 29, in the westbound lanes (see Figure 31). The existing cross section consisted of a 7-inch CRC pavement over a 4-inch BAM subbase. In 1999, the section had an ADT of 12,200 vehicles with 35 percent trucks.

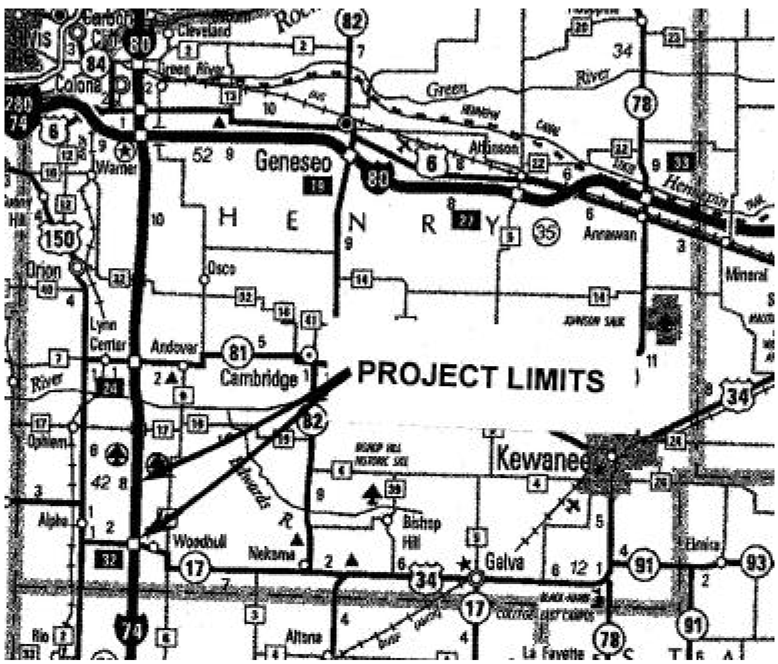

Figure 31. Location of I-74 Project Constructed 1999.

<u>Preconstruction Condition</u>

The CRS value was obtained to determine the existing condition of the pavement. The CRS value of the section was 5.1, fair condition, in 1998. Main distresses observed were punchouts, local areas of pavement breakup, and failing patches (see Figure 32). These distresses are not uncommon for a thin CRC pavement section. The section was very rough, with an IRI over 300 in 1998.

Figure 32. Preconstruction Condition (I-74 1999).

FWD testing was conducted to determine appropriate areas to core. Cores and soil samples were taken to help evaluate possible problems that might be encountered during construction. In situ soil strength data were gathered to determine if a minimum level of soil support for the rubblizing process existed. IBVs were found to be from 3 to 5, an acceptable level to support rubblizing operations.

Test Section Description

The contract consisted of one control section and one test section. From station 50+400 to 50+000, a PCC patch and overlay with 5.5 inches bituminous concrete was performed. From station 49+300 to 46+100, the existing CRC pavement was rubblized and used as a subbase. An 11-inch bituminous concrete overlay was constructed on top of the rubblized pavement.

Construction

The project was constructed in July 1999. The operation proceeded in one lane while the public continued traveling in the adjacent lane. The equipment used, construction sequence, and challenges encountered are discussed in the next sections.

Equipment

The MHB and Z-grid roller were used on this project. At optimum performance, the rubblizing progressed at about 1.4 miles per day.

Sequence

Underdrains had been placed under a previous contract. The driving lane was rehabilitated first, as shown in Figure 33. The existing concrete pavement was rubblized and the binder lifts, a total thickness of 9 inches, were placed. Then traffic was switched to the driving lane so the passing lane could be rehabilitated. Once binder was placed on both lanes and shoulders, the 2-inch surface was constructed.

Figure 33. Driving Lane Rubblization (I-74 1999).

Challenges

No challenges were encountered on this project.

Performance

Performance has been monitored since construction. Items examined include CRS values and visual distress surveys, IRI, rutting, and FWD testing.

CRS Values and Visual Distress Surveys

The CRS value in 2000 was 7.8, considered excellent. A distress survey was performed in 2000. At that time, three low-severity transverse cracks, or 6.0 cracks per lane-mile, were apparent on the control section. One 10-foot long low-severity longitudinal crack, or 2.5 feet per lane-mile, was present in the rubblized section.

IRI and Rutting

The IRI and rutting data were collected in 2000. The IRI and rutting data for both sections are contained in Table 20. The IRI values are similar to new pavements. Rutting is minimal on both sections.

Table 20. IRI and Rutting Data (I-74 1999).

	5.5" Overlay		Rubblize & 11" Overlay	
Year	IRI (in./mi.)	Rut (in.)	IRI (in./mi.)	Rut (in.)
2000	91	0.02	77	0.02

FWD

FWD data were collected immediately after construction of the pavement. The average deflection data are summarized in Table 21. The deflection of the rubblized section should decrease as the rubblized material is seated by traffic and the asphalt ages.

Table 21. FWD Data for All Sections (I-74 1999).

Year	Section	Temp. (°F)	Deflection (mils)	Area (in.)	E_{RI} (ksi)
1999	Control	80	7.9	25.6	8.6
1999	Rubb. 11"	80	16.5	20.9	7.8

Project Summary

With the limited amount of performance data available, performance of this section is acceptable. Deflection data, IRI, and rutting are similar to those seen on other rubblized sections. The lack of construction challenges indicate good project selection and construction practices.

STATUS OF RUBBLIZING

Over the last ten years of experience with the rubblizing procedure, documents have been developed to help the districts evaluate the feasibility of rubblizing and to construct a project. Through construction experience, knowledge has been gained into project evaluation to ensure good candidates are chosen for rubblization. In addition, the cost factors to consider have been identified. These areas are described in this section.

Documents for Rubblizing Projects

In May 2001, three documents were issued to the districts. These documents are the "Guidelines for Rubblizing PCC Pavement and Designing a Bituminous Concrete Overlay," the "Special Provision for Rubblizing PCC Pavement," and the Construction Memorandum "Rubblizing PCC Pavement and Placing a Bituminous Concrete Overlay." These documents are described in more detail below and are included in Appendix B.

Guidelines for Rubblizing PCC Pavement and Designing a Bituminous Concrete Overlay

This document is intended to be used by the designer to: review the existing pavement structure; identify design considerations; and prepare a request for review and approval. The existing pavement structure review includes the condition of the existing pavement and the subgrade. Design considerations include which equipment to use for rubblization, drainage issues, and the bituminous concrete overlay thickness design, among other things.

Because rubblizing has not been incorporated into the Department's rehabilitation policy, a thorough project review by both the Bureau of Design and Environment (BD&E) and the Bureau of Materials and Physical Research (BMPR) needs to be conducted before permission to rubblize is granted. The guidelines include a section on preparing the review request.

Special Provision for Rubblizing PCC Pavement

This special provision is included in the contract documents for a project. All steps taken in the rubblizing process and construction of the overlay are detailed. Measures to take when soft subgrade or insufficient breaking are encountered, as well as the type of paver to use, and when to open the roadway to traffic, are also addressed in the special provision.

Construction Memorandum "Rubblizing PCC Pavement and Placing a Bituminous Concrete Overlay"

This document is intended to give the Department's Resident Engineer on the project background about rubblizing, the equipment, sequence of construction, and other construction considerations.

Project Evaluation

There are many things to consider when deciding to rubblize a project. The pavement structure may be inappropriate for rubblizing for two reasons: either the subgrade is too soft to support the rubblizing equipment, or the pavement does not have distresses for which rubblizing is the best alternative. If the subgrade is too soft, it will not provide adequate resistance to the applied force and the pavement will not break sufficiently. In the long term, larger pieces of concrete can lead to reflective cracking of the overlay. Because bituminous concrete overlays typically fail due to reflective D-cracking and reflected joints and patches, pavements with extensive D-cracking and/or poor joint conditions and cracked slabs are the best candidates for rubblizing.

The elevation of the mainline pavement will be higher as a result of the rubblizing process, due to the added thickness of bituminous concrete overlay required for the rehabilitation. Consideration should be given to overhead and at-grade structures. If there are many structures in the project limits, the elevation change may be problematic. If the structures can be raised to provide clearance, or to meet the mainline elevation, rubblizing is feasible. Another option is to gap the rubblizing in those areas and either do a minimum rehabilitation or complete reconstruction.

Alignment and grade corrections, as well as future capacity improvements, should also be considered. Because rubblizing is a rehabilitation, alignment and grade changes cannot be accomplished as part of the process. If additional lanes will be added in the future, rubblizing may not be the best option because future lanes cannot be tied to the rubblized concrete.

Any rehabilitation option that uses bituminous concrete may need additional rehabilitation after approximately ten years of service, depending on traffic (7). This is due to aging of the bituminous concrete surface. Future rehabilitation of the overlay of rubblized pavement should only consist of milling and replacing the surface. The deterioration of the concrete below the overlay has been arrested by the rubblizing process, eliminating the need for additional patching of the underlying concrete. However, future rehabilitation of an overlay of intact concrete usually requires additional patching of the underlying concrete along with removing and replacing the surface.

If a long life at a high level of serviceability is desired, reconstruction should be considered. If a moderately long life at a good level of serviceability is desired, rubblizing with a bituminous concrete overlay is an excellent option. For some projects, the pavement may not be in poor enough condition, rubblizing may not feasible, or capacity improvements or complete reconstruction in the near future may be planned. A patch and standard overlay or thick overlay should be considered for these projects.

Cost Analysis

A cost analysis should be conducted to determine if rubblizing is the most cost effective alternative. Table 22 includes a list of items that should be considered in the cost comparison. All items may not be relevant to every project. For example, some projects already have functioning underdrains, so they would not be needed.

Table 22. Items for Cost Analysis.

Item	Rubblize and B.C. Overlay	Patch and B.C. Overlay
Aggregate Shoulders	√	√
Bituminous Shoulders	√	√
Bituminous Binder	√	√
Bituminous Surface	√	√
Centerline Milling		√
Grading	√	
Level Binder		√
Milling of Existing Bit.	√	√
Pavement Patching		√
Prime Coat		√
Rubblizing	√	
Traffic Control	√	√
Underdrains	√	√

Rubblizing costs on the seven projects averaged $1.85 per square yard and has decreased over time. The amount of patching required is usually the driving force in the cost analysis. Historically, if the amount of patching exceeds approximately 12 percent of the project area, rubblizing is more cost effective.

In 2001, another project was rubblized on Illinois Route 38, west of the 1994 project. This project is a typical two-lane rural state route. It is a JRC pavement with 100-foot joint spacing. As part of the preliminary investigation, the District estimated the amount of patching that would be needed if rubblizing was not performed. They submitted the project to the BD&E and BMPR for approval, and included a cost estimate. See Tables 23 and 24.

Table 23. Cost for Rubblizing and 6-inch Bituminous Concrete Overlay.

Item	Quantity	Unit Price	Total Cost
Rubblizing	154,534 yd^2	$1.92	$296,705
Bituminous Binder	34,069 tons	$29.94	$1,020,026
Bit. Surface Course Type 2	17,034 tons	$31.30	$533,164
Bituminous Surface Removal	46,427 yd^2	$2.09	$97,032
Aggregate Base Course	10,362 tons	$12.25	$126,935
Exc. and Grade Exist. Shldr.	6,000 units	$17.22	$103,320
Pipe Underdrains 4"	121,949 feet	$4.10	$499,991
Pipe Underdrains (special)	3,750 feet	$9.14	$34,275
Conc. Headwall for Pipe Drains	250 each	$145.00	$36,250
Traffic Control	1.0 L Sum	$150,000	$150,000
		Total	$2,897,698
		$241,475 per 2-lane mile	

Table 24. Cost for PCC Patching and 2.50-inch Resurfacing.

Item	Quantity	Unit Price	Total Cost
Class B Patching	29,362 yd^2	$112.88	$3,314,383
Level Binder (Machine Method)	8,518 tons	$30.84	$262,695
Bit. Surface Course Type 2	12,947 tons	$31.98	$414,045
Traffic Control	1.0 L Sum	$300,000	$300,000
		Total	$4,291,123
		$358,191 per 2-lane mile	

The District estimate allowed for 19 percent patching. For patching and resurfacing to be cheaper than rubblizing, the patching would have to be no more than 11.4 percent.

SUMMARY AND CONCLUSIONS

By 2000, ten projects had been rubblized in Illinois, seven of which have been closely monitored. Construction was feasible on all projects, using two different types of breaking equipment.

On I-57, constructed in 1990, the difficulty of rubblizing with the PB-4 while maintaining traffic was evident.

The IL 38 project demonstrated the minimum soil strength needed to permit adequate breaking of the concrete, an IBV of 3 to 5. The minimum binder thickness to prevent damage to the rubblized pavement by traffic was found to be 4 inches.

On the I-55 Frontage Road, the minimum binder lift thickness needed to achieve density was 1.75 inches.

On I-57, constructed in 1996, the MHB did not impact the traffic near to the extent the PB-4 did on the 1990 project. Also, the use of a tracked paver proved to disturb the rubblized layer much less than the rubber tired paver.

The rubblizing operation on I-70 progressed as an inlay. Milling needed to be 12.5 to 13 feet wide to allow enough room for the rubblizing equipment between the shoulder and the adjacent lane.

The I-57 project, constructed in 1997, showed the need to rubblize a small portion of the ramps, rather than rubblize narrower than 12 feet in two passes.

The I-74 project demonstrated good project selection combined with good construction practices.

All seven projects are performing well to date with no additional rehabilitation needed. The thickness of the I-55 Frontage Road project may be insufficient. The I-57 project, constructed in 1997, has had excessive rutting, which was not related to the rubblized concrete layer.

Documents have been developed to guide the districts in designing and constructing projects. In addition, project evaluation and cost analysis factors have been identified for consideration during the project selection phase.

Rubblizing with a bituminous concrete overlay has been a successful rehabilitation method on both interstate and non-interstate projects. Reflective cracking from D-cracking, as well as joints, cracks, and patches has been minimized. Over the course of ten years, it has been shown that bituminous concrete overlays of rubblized concrete pavements have performed better than patching and overlaying with bituminous concrete.

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APPENDIX A. I-57 CONSTRUCTED 1997 RUTTING ANALYSIS

Illinois Department of Transportation

Memorandum

To: Files

From: Amy Schutzbach

Subject: Rubblizing slice operation on *

Date: July 15, 1999

* Contract No. 98387
F.A.I. 57
Section (91-2, 91-3-1)RS, (91-3HB)I
Union County

On June 30, 1999, two full-depth slices and 10 full-depth cores were taken from the southbound driving lane on the subject rubblizing project. Matt Mueller, Jim Trepanier, and myself were present during the operation, as were Bruce Peebles and John Geiselman of District 9, and Marshall Thompson, Sam Carpenter, and Bill Vavrik of the University of Illinois. The pavement was designed to be constructed with a 4.5-inch binder lift, a 2.5-inch binder lift, and a single 2.0-inch surface lift. The surface material was actually placed in two lifts, level binder and surface, to make up for a binder thickness deficiency.

The slice locations were at STA 50+898 and STA 48+568. At each slice location, five cores were taken across the driving lane at the right (outside) edge of the driving lane, in the outer wheelpath, in the center of the lane, in the inner wheelpath, and at the left edge of the driving lane. Three 1-foot by 4-foot intact pieces were removed adjacent to the core locations. Every effort was made to ensure that the pavement pieces had clean saw-cut faces across the pavement width.

The attached photos document the removal process. Saw cuts were extended into the shoulder to allow for easy removal. The waste piece at the outside edge of the lane was pried up with the bucket of a backhoe. The six waste pieces were removed; most of them split at the interface between the two binder lifts. The thin pieces adjacent to the “keeper pieces” were pried out by hand. An attachment that looked like a little shelf was bolted onto the backhoe bucket and the “keeper pieces” were rocked onto the shelf and lowered onto pallets in our trucks.

At STA 50+898, ruts in the outer wheelpath were measured to be 0.45 inch. Of the five cores taken across the pavement, the cores taken at the right edge of the driving lane and at the left edge of the driving lane were recovered intact, while the cores taken in the outer wheelpath, the center of the lane, and the inner wheelpath were debonded between the first and second binder lifts. The first lift of binder was a nominal 4.5-inch thick lift, so this break occurred at approximately the mid-depth of the 9-inch design thickness. The two intact cores broke at the first binder lift-second binder lift interface during transport. The three pavement pieces were recovered intact, but adjacent pieces broke between the first and second lifts of binder. This first binder lift-second binder lift interface was very evident on the three intact pavement pieces. When considered with the fact that three of the five cores were recovered with the first and second binder lifts debonded, this would suggest that the bond between the first and second lifts of binder was in a weakened state. The level binder-second binder lift interface appeared firmly bonded and was more difficult to discern.

At STA 48+568, rut depths of 0.35 inch in the inner wheelpath and 0.3 inch in the outer wheelpath were measured. Of the five cores taken across the pavement, all five were recovered intact, as were the three 1-foot by 4-foot pavement pieces. Bond lines between the first and second lifts of binder were again very evident.

String lines were held along the bond interfaces to determine where the rutting occurred. Rutting was evident in the two surface courses; ruts were apparent on the pavement surface and the interface between the bottom surface (level binder) lift and the second lift of binder was wavy. The bottom of the second lift of binder and the top of the first lift of binder appeared relatively straight, suggesting that the bulk of the rutting occurred in the surface course.

Based on our field observations, a few statements could be made:

- The rutting does not seem attributable to the rubblizing process. The results of the Falling Weight Deflectometer (FWD) testing, discussed in our report of March 24, 1999, indicate that the rubblized pavement/subgrade is providing more than adequate support for the pavement structure. This finding was visually verified during the slice observation. Had the rubblized pavement/subgrade been the cause of the rutting due to weak support, rutting would have been evident throughout the pavement structure in the wheelpaths. This was not found in the field. In addition, rutting of at least 0.4 inch was measured in the field in a non-rubblized section of the driving lane near the Anna exit, suggesting that the rutting was more laydown or mix-related.

- Based on field observations of lift thicknesses and movement throughout the pavement structure, the majority of the rutting seems confined to the two surface lifts. Our laboratory investigation supports these observations. Originally designed as 2-inch surface course, the surface material was actually placed in two lifts: level binder and surface, to make up for a binder thickness deficiency. The lab investigation showed that thicknesses of these two lifts ranged from 0.6 to 1.6 inches. Lifts these thin are difficult to place and compact, as aggregate is broken and density measurements are unreliable. The use of level binder on the interstate is precluded for these reasons.

In our previous laboratory investigation, surface course void levels from cores taken at the left edge of the driving lane, in the center of the lane, and at the right edge of the driving lane averaged 6.07 percent. The surface course void levels from cores taken in the inner and outer wheelpaths averaged 3.38 percent. Three of the four wheelpath surface cores had void levels of 3.0 percent or less. Void levels or 3.0 percent and less in one-year old pavements, as this pavement was at the time of the laboratory investigation, are of concern.

- Eight of the 10 cores studied in the laboratory investigation were debonded between the two binder lifts in the driving lane. Three of the 10 cores taken in the driving lane during the slice operation were debonded at this interface, and two more broke at this interface during transport to Springfield. Although the pavement pieces taken during the slice operation were removed intact, adjacent pieces broke free at the first binder lift/second binder lift interface. A weak bond appears to exist between the two binder lifts in the driving lane, and in some areas may have already debonded.

  This weakened bond state means that the pavement design assumption of an intact 9- inch thick bituminous concrete layer was not uniformly achieved. Achieving the design thickness is more critical on a rubblized project than on an overlay because of the different failure mechanisms. Fatigue in the bituminous concrete controls the thickness design for rubblized sections. The effect of a weakened bond state results in a shortened life expectancy, but it is difficult to quantify just how much because there is some friction between the layers. This weakened bond state was found at four randomly chosen driving lane locations, so it is reasonable to assume that this weakened bond state is present throughout the driving lane. There is no way to identify bond status short of coring or taking a slice. The FWD will not identify locations of debonding because friction between the layers masks the effects of debonding.

Rutting data on this project was obtained with the Department's automated data collection equipment in both 1998 and 1999. The average rut depth in the driving lane in August of 1998 was 0.249 inch, while the average rut depth in the driving lane as of June 22, 1999 was 0.23 inch. The rutting does not appear to have increased over the past year, but the hot, wet weather that occurred prior to the rutting in 1998 has not been apparent yet in 1999. It is difficult to predict if additional rutting will occur under similar hot, wet conditions.

The recommended rehabilitation strategy for the driving lane would be to mill out the surface and the top lift of binder, prime the remaining binder lift and place a single 2.5-inch lift of bituminous concrete binder and a single 2.0-inch lift of bituminous concrete surface. Traffic should not be allowed on the pavement until the new binder lift has been placed to avoid stressing the subgrade. We would also recommend that a different bituminous concrete surface mixture design be used, since the present one appears to be rut-prone.

A rehabilitation strategy for the passing lane is less clear cut. Rutting measurements in the passing lane averaged 0.103 inch in 1998; similar measurements for 1999 won't be taken until later in the summer. The same binder mixture was placed in the passing lane as in the driving lane, but the passing lane binder lifts were placed in August of 1997, whereas the driving lane binder lifts were placed in October of 1997. The passing lane has never been cored or sliced, so the bond state between any of the lifts of the passing lane is not known. Random coring throughout the passing lane would assess the bond state between the binder lifts and would assist in determining passing lane rehabilitation strategy.

The same surface mixture was placed in the passing lane, however, so it could reach similar rutting levels if 100 percent of the southbound traffic runs on the passing lane during rehabilitation of the driving lane. The rutting would be especially apparent if the rehabilitation occurred during hot, rainy weather. The surface mixture in the driving lane should be removed.

We plan to do additional testing on the samples taken during the slice operation. The cores will be split to determine in-place tensile strength and moisture damage levels. Interface planes on the pavement pieces will be marked and measured to determine lift thicknesses and material flow.
Gyratory testing with the Gyratory Testing Machine will be conducted on material from each lift to evaluate mixture instability and rutting potential. The University of Illinois is interested in examining the bond strength between the lifts as well as the shear strength of the mix. This information will prove useful from a mix design standpoint.

AMS/ams/slcefile.doc

APPENDIX B. RUBBLIZING DOCUMENTS

SUBJECT: **Guidelines for Rubblizing PCC Pavement and Designing a Bituminous Concrete Overlay**

DATE: **June 1, 2001**

Applicability

These guidelines are to be followed to: (a) review the existing pavement structure, (b) identify design considerations, and (c) prepare a request for review and approval, for rubblizing PCC pavement and designing a bituminous concrete overlay.

Background

With many pavements nearing the end of their design lives, and extensive patching sometimes needed to rehabilitate a pavement section; rubblizing may result in both cost and time savings over standard techniques.

Rubblization is part of a rehabilitation process in which existing portland cement concrete (PCC) pavement is broken (in-place) into small pieces and compacted to create a uniform base. Rubblization should be considered as an alternative to extensive pavement patching with a standard bituminous concrete overlay or a thick, structural bituminous concrete overlay for PCC pavements with severe distresses.

The benefits of rubblization are: most patching of the existing PCC pavement is eliminated; a more uniform base is provided; reflective cracking of the bituminous concrete overlay, caused by rocking and thermal movement of PCC panels and poor load transfer, is minimized; and a moderately drainable base is produced.

These guidelines encompass the evaluation of an existing pavement structure to determine if the section can support the rubblizing construction process, and design and construction steps needed to successfully use this option. The use of rubblizing requires close attention to subgrade support. This technique requires sufficient thickness of the rubblized pavement and subbase structure to protect the subgrade during construction operations.

Procedures

The selection of rubblization with a bituminous concrete overlay should be the result of a thorough review of the existing pavement structure, design issues, and examination of other alternatives.

(a) Review of the Existing Pavement Structure

A thorough investigation of the existing pavement and subsurface should be conducted. The purpose of the investigation is to determine if the pavement section can be successfully rubblized. It is essential, that only constructible sections be selected for this rehabilitation option. This requires adequate support from the subgrade, subbase, and rubblized pavement section for construction activities. If conditions exist that would result in extensive removal and replacement of the existing pavement, or the subgrade is weak and would result in severe construction problems, the designer should consider other rehabilitation options.

(1) Preliminary Soils Review

Before ordering an extensive subgrade investigation, the designer should contact the District's Geotechnical Engineer to discuss the proposed rubblizing section. From the pavement cross section, soil maps, and typical Immediate Bearing Values (IBVs) of soils in the area; the designer and Geotechnical Engineer should determine if the rubblized section will protect the subgrade, as outlined in the Department's Subgrade Stability Manual.

If the rubblized pavement will not provide adequate cover for potentially soft subgrades, rubblizing should not be considered as an option. Rubblizing destroys the slab action of the PCC pavement; and if an unstable subgrade is encountered during construction, the pavement section may require expensive change orders to reconstruct.

If it appears that the pavement can be rubblized, then a detailed pavement and subsurface investigation is needed to verify constructability of the pavement.

(2) Detailed Pavement and Subsurface Investigation

After passing a preliminary review, the District may request Falling Weight Deflectometer (FWD) testing from the Bureau of Materials and Physical Research to assist in planning coring locations. A detailed pavement and subsurface investigation should be conducted and a report prepared to specifically address the following points:

- AC overlay thickness (if present).
- Subbase condition and thickness (if present).
- Subgrade IBV from Dynamic Cone Penetrometer (DCP) test.
- Subgrade soil samples (if needed for further evaluation).
- Survey of existing drainage conditions.
- All shoulders' ability to carry traffic while under construction.
- Identification of locations where pavement removal and replacement, or alternative rehabilitation is recommended.
- Subgrade stability during rubblization.

The District's Geotechnical Engineer should develop a coring, DCP, and soil sampling plan for the section. In general, a minimum of 1 core per lane every 0.8 km (2 cores per lane-mile) should be taken. If FWD testing is not obtained, a minimum of 1 core per lane every 0.4 km (4 cores per lane-mile) should be taken. Core locations should be in representative cut and fill locations, and staggered between lanes. Additional coring and testing may be needed to define limits of weak subgrade areas.

The condition of any recovered stabilized material should be noted as being sound (intact and like new), slightly deteriorated (20% or less unsound or missing material), or deteriorated (more than 20% unsound or missing material). The overall condition of the subbase should be reported as a percentage of cores in each of these groups (i.e. 60% - sound, 30% - slightly deteriorated, and 10% - unsound).

After the core is removed, the DCP should be run in the hole for subgrade IBV. It is preferable to record single blow increments, to a depth of approximately 750 mm (30 in.) below the bottom of the pavement. If a granular base exists, the DCP may be driven through it and the depth determined from the change in IBV. A 3- to 4-kg (6- to 8-pound) soil sample should be taken and stored in an air-tight container for later testing if required. Forms BC 435 and Mat 508A shall be used for documentation.

After the field survey is complete, typical IBVs should be developed, along with cross section data and condition of each layer. The data from each test location should be presented in table form including depth, penetration, and calculated IBV.

For the 300 mm (12 in.) of subgrade directly below the pavement, additional analysis is required. The top of the subgrade is broken into two layers, from 0 to 150 mm (0 to 6 in.), and 150 to 300 mm (6 to 12 in.). The average IBV is determined for each layer and plotted on Figure 1, using the pavement cross-section information. Once the data is plotted, a determination should be made as to what type of Rubblizing Method should be specified.

For very limited areas of very soft subgrades, the designer may remove and replace the pavement, omit rubblizing, or perform a cracking and seating operation (Bureau of Design and Environment Manual, Chapter 53) so the pavement can bridge weak subgrade areas where undercutting is not cost-effective. These areas should be identified on the plans. If it is found that several short or a few substantial segments of the project require omissions, or removal and replacement of the pavement; then other rehabilitations should be considered.

The pavement and subsurface report should include the following:

- Cross section of pavement section(s).
- Core soundness and condition.
- Summarized results of Subsurface Investigation.
- Data plotted on Subgrade Rubblizing Guide.
- Number and locations of transitions to meet mainline structures.
- Clearances for overheads.
- Utilities and culverts.
- Location of any buildings or structures within 15 m (50 ft) of the rubblization.
- Location and condition of underdrains.

(b) Design Issues

There are many design issues that must be considered before the project can be submitted for review and approval. These include equipment selection, drainage considerations, priming, bituminous concrete overlay thickness design, traffic control, and specification of material transfer devices (MTDs).

(1) Equipment Selection

A pavement breaker and self-propelled rollers are the major equipment necessary to rubblize a PCC pavement. The pavement breaker should be selected to meet the project's needs with respect to traffic control, staging, and subgrade support limitations. The following equipment characteristics should be considered when making a decision on breaker selection:

a. Method I - Multi-Head Breaker (MHB)

The MHB is a self-propelled unit with multiple drop-hammers mounted at the rear of the machine. The hammers are set in two rows, and strike the pavement approximately every 115 mm (4.5 in.). The hammers have variable drop heights and variable cycling speeds. The Model MHB Badger Breaker, manufactured by Badger State Highway Equipment, Inc., Antigo, Wisconsin (*http://www.antigoconstruction.com/*) is acceptable.

The equipment has the ability to break pavement up to 4 m (13 ft) wide, in one pass. The rate of production depends on the type of base/subbase material, and is approximately 1.6 lane-km (1.0 lane-mi) per day.

The Z-pattern steel grid roller, a vibratory roller with a grid pattern, must be used in conjunction with the MHB to complete the breaking process. A Z-pattern grid is attached transversely to the drum surface. This roller further breaks flat and elongated material into more uniform pieces. The vibratory roller is self-propelled, with a minimum gross weight of 9 metric tons (10 tons).

Method I should be specified if there is any question of the rubblized section's ability to support construction equipment. The rubblized section and subgrade still must be able to support compaction equipment and loaded trucks without rutting or dislodging the rubblized PCC pavement.

The MHB should be specified if the roadway is to remain open to traffic and encroachment into the adjacent lane cannot be accommodated. Encroachment of the MHB into the adjacent lane is similar to the rolling operation of bituminous paving.

The paving operation may work directly behind the breaking operation, in such a manner that the lane may be rubblized and overlaid for opening to traffic at the end of the day.

Caution should be used if buildings are within 15 m (50 ft) of the rubblizing operation, especially in an urban setting. Buildings which may be sensitive to vibration should be identified in the project report, with an alternate method of localized pavement breaking recommended. Alternate breaking methods, such as a skid steer mounted jack hammer, should be considered or pavement rubblizing omitted near vibration sensitive buildings.

Underground utilities and drainage structures must be identified for protection. An omission in the breaking operation may be required, over utilities and drainage structures. These omitted areas shall be broken with an alternate breaking method.

b. Method II - Resonant Frequency Breaker with High Flotation Tires

This method utilizes a resonant frequency breaker with tires, which have pressures below 415 MPa (60 psi). This allows operation on pavement sections that are thinner or have soft subgrades.

A resonant frequency breaker is a self-propelled unit that utilizes high frequency, low amplitude impacts with a shoe force of 8,880 N (2,000 lb) to fracture the PCC pavement. The shoe, or hammer, is located at the end of a pedestal, which is attached to a beam and counter weight. The breaking principle is that a low amplitude, high frequency resonant energy is delivered to the concrete slab, resulting in high tension at the top. This causes the slab to fracture on a shear plane, inclined at about 35 degrees from the pavement surface. The shoe, beam size, operating frequency, loading pressure and speed of the machine can all be varied.

The breaking begins at the centerline and proceeds to the outside edge of the pavement. The breaking pattern is approximately 200 mm (8 in.) wide, and requires 18 to 20 passes to break a 3.6 m (12 ft) lane width. The rate of production depends on the type of base/subbase material, and is about 1.0 lane-mi. (1.6 lane-km) per day.

The Resonant Breaker has very heavy wheel loads of 89,000 N (20,000 lb). The broken pavement, shoulder, and subgrade must be adequate to support multiple passes of the equipment. The Resonant Breaker encroaches 1.0 to 1.5 m (3 to 5 ft) into the adjacent lane to rubblize pavement near the center line. The pavement section/shoulder must be structurally adequate for traffic to be moved 2.0 to 2.5 m (7 to 8 ft) from the centerline and onto the shoulder. The use of the Resonant Breaker is best suited on roads that can be closed to traffic, and support the breaker’s weight.

The Resonant Breaker produces limited vibrations. Caution should be used with vibration sensitive buildings that are within 3 m (10 ft) of the rubblizing operation.

Utilities or culverts within 150 mm (6 in.) of the PCC pavement bottom need to be protected, as described in Method I.

c. Method III - Resonant Frequency Breaker

This is the same basic machine as in Method II. However, it does not utilize the high flotation tires. This results in limiting usage as shown in Figure 1.

d. Method IV (Breaking device not specified)

This method can be specified if Methods I, II, and III could be used without restrictions to subgrade support, traffic, staging, or structures as noted above.

(2) Drainage Considerations

The Department's longitudinal underdrain policy (Design Manual, Chapter 53) should be followed. Underdrains are recommended, at a minimum, in sag areas of vertical curves. French drains, which are capable of draining the entire depth of the section, are acceptable for isolated areas. For sections where underdrains will not be installed, the designer should consider limiting the amount of time the rubblized pavement may be left without an overlay, to minimize delays from rain saturation. If existing underdrains are functioning, no additional drainage features are necessary.

(3) Priming

The rubblized surface should be overlaid without priming. Priming adds an extra step and curing period, which delays construction with no benefit to the finished product.

(4) Bituminous Concrete Overlay Thickness Design

a. Overlay Thickness Design Based on Actual Traffic

The designer should determine the required Traffic Factor (TF) needed for the design period [as noted in Section 54-5.01(g) of the Design Manual], using a recommended design period of 20 years. Design periods less than 10 years should not be considered. The bituminous overlay needed on top of the rubblized section is determined using attached Figure 2. All designs are rounded up to the next 5 mm (0.25 in.). The design thickness, as a function of district location and traffic factor, is determined as follows:

1. Districts 1 and 2

Use the thickness line for "Districts 1 and 2."

2. Districts 7, 8 and 9

Use the thickness line for "Districts 7, 8, and 9."

3. Districts 3, 4, 5 and 6

Interpolate the pavement thickness based on the location of the proposed pavement section, in relation to the thickness lines for "Districts 1 and 2", and "Districts 7, 8, and 9".

b. Minimum Bituminous Concrete Overlay and Lift Thicknesses

The minimum bituminous concrete overlay thickness for rubblized pavement is 150 mm (6 in.). The first lift of the overlay should be 75 to 100 mm (3 to 4 in.).

This thickness allows good compaction on and minimizes dislodging of the rubblized base. The surface lift should be 50 mm (2 in.). For pavement overlays which are 175 mm (7 in.) or less, surface lifts of 38 mm (1.5 in.) are allowable. Contact the Bureau of Materials and Physical Research if first lifts less than 75 mm (3 in.) are desired.

(5) Traffic Control

Traffic may be maintained during much of the rehabilitation operation. The road may be used after the installation of underdrains and the milling of any existing bituminous concrete overlay. The safety of open trenches, lane to lane drop-offs, high shoulders, and the condition of the exposed pavement surface should be considered when determining if the road can be reopened to traffic.

No traffic (including unnecessary construction traffic) should be allowed on the fractured pavement surface once the breaking operation begins. All bituminous concrete binder lifts should be paved before traffic is allowed onto the section. If staging requires that the pavement be opened to traffic before all the binder layers are in place, contact the Bureau of Materials and Physical Research to review the structural impacts.

Edge differentials in elevation of rubblized pavements can be substantially greater than standard overlays, and may require additional traffic control measures. The designer should evaluate the overall design and traffic staging to determine if any additional traffic control may be required. The designer should also evaluate differentials in elevation if milling to bare pavement is needed.

(6) Specification of Material Transfer Devices (MTDs)

The use of MTDs on the rubblized base must be evaluated on a case by case basis, due to the weights and axle configurations of the equipment. Contact the Bureau of Materials and Physical Research to perform an analysis.

(7) Construction Sequence

The general sequence of construction should be as follows:

- Install underdrains or French drains, as required.
- Remove any existing bituminous concrete overlay to the staged width.
- Remove and replace any existing unsound bituminous repair materials.
- Rubblize the pavement.
- Compact the broken pavement.
- Pave the binder lifts of the bituminous concrete overlay.
- Allow traffic on sections which have adequate thickness, as shown on the plans (if needed).
- Pave the surface of the bituminous concrete overlay.

(8) Other Design Issues

Any bituminous material on the pavement from pothole patching may be left in place. If there are any full-depth bituminous concrete patches in the section, soundness of the patch material should be determined. Bituminous concrete patches should be rated in the same manner as subbase in Section (a)(2). Visually indeterminate patches may be investigated with a limited coring program. If a bituminous concrete patch is unsound, the material should be removed. When traffic is maintained during the patching operation, the replacement material should be a Class C or D patch. If concrete is the replacement material, it shall be rubblized.

If the unsound patch is greater than 1 sq m (10 sq ft), bituminous concrete binder mixture shall be used. When the road is closed to traffic and the unsound patch is less than or equal to 1 sq m (10 sq ft), the replacement material may otherwise be aggregate. The aggregate shall be a Class D Quality (or better) crushed stone, crushed slag, crushed concrete, or crushed gravel meeting a CA 6 or CA 10 gradation; according to Section 1004 of the Standard Specifications.

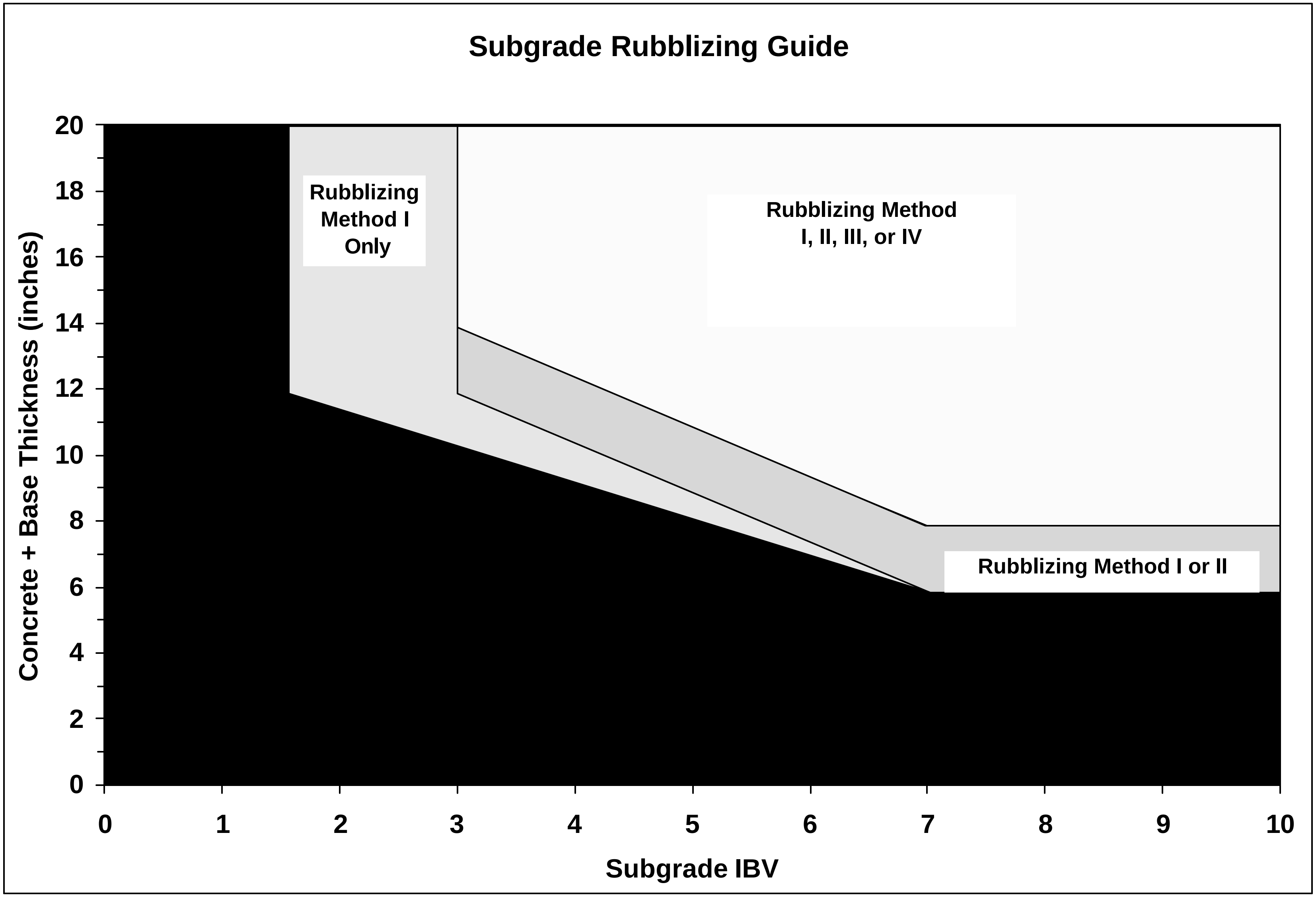
Partial-depth bituminous concrete patches may be left in place during rubblization. If partial-depth patches prevent proper breaking of the PCC pavement, a skid steer loader (with a jack hammer attachment or similar device) may be used to complete breaking in these areas.

The rubblizing process will increase the pavement width 25 to 75 mm (1 to 3 in.) per 2-lane width, and encroach slightly into the underdrain trench. This has not caused performance problems with sand trench and pipe type underdrains to date. If the Resonant Breaker is used, the driving of heavy wheel loads directly over the underdrain trench should be avoided as much as possible. Wheel loads directly over the underdrain trench are of less concern if the existing shoulder is in sound condition.

(c) Review and Approval

All proposed rubblizing projects must be submitted for approval to the Bureau of Design and Environment. At a minimum, the submittal should include the following: 1) detailed pavement and subsurface investigation report, 2) selection of breaking equipment method, 3) existing and proposed cross sections, 4) traffic information, and 5) discussion on why rubblization is the preferred method of rehabilitation over other alternatives. Submitting a copy simultaneously to the Bureau of Materials and Physical Research will facilitate a timely review.

Attachments



Subgrade Rubblizing Guide
Rubblizing Method I Only
Rubblizing Method I, II, III, or IV
Rubblizing Method I or II
Concrete + Base Thickness (inches)
0
2
4
6
8
10
12
14
16
18
20
0
1
2
3
4
5
6
7
8
9
10
Subgrade IBV

Figure 1

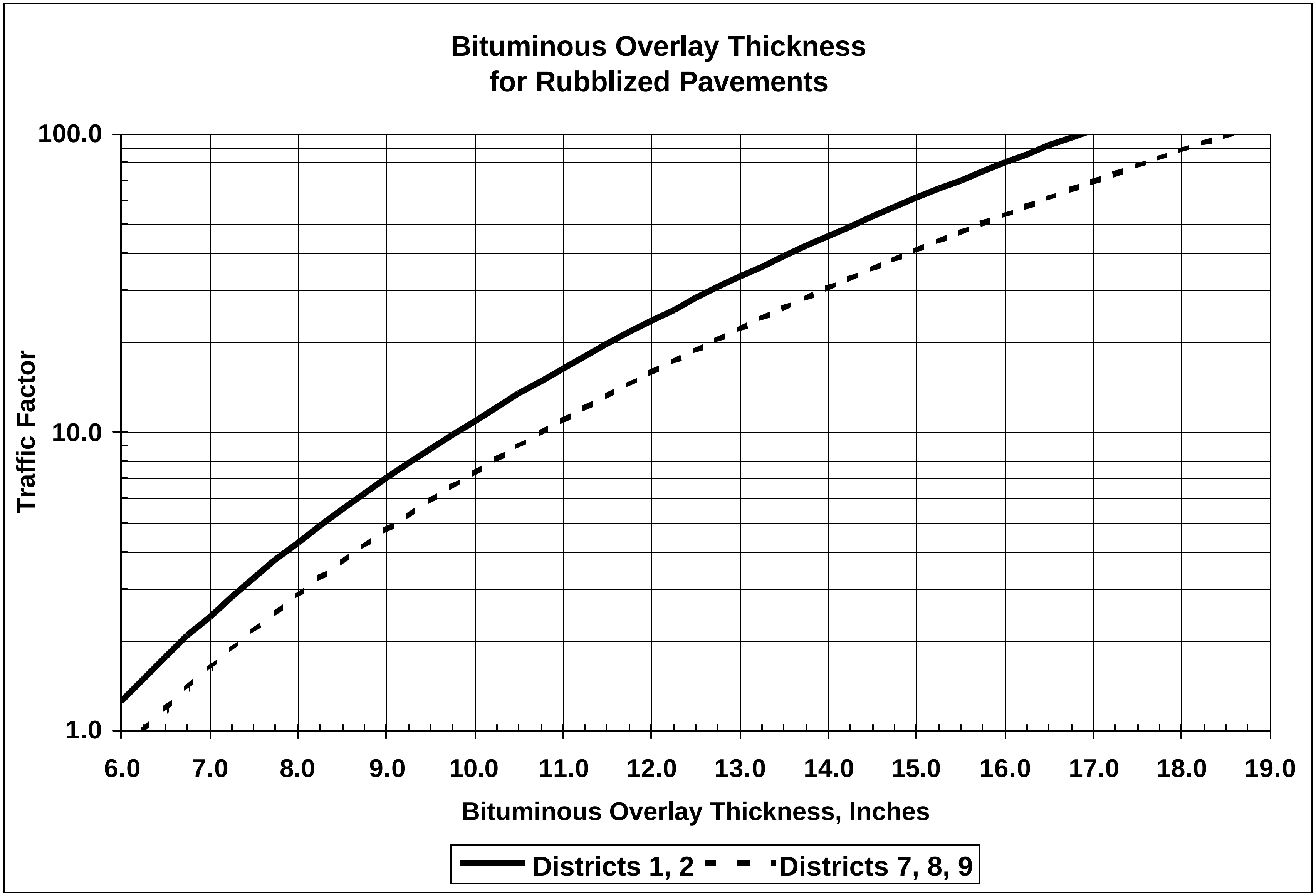

Bituminous Overlay Thickness
for Rubblized Pavements
100.0
10.0
1.0
Traffic Factor
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
Bituminous Overlay Thickness, Inches
Districts 1, 2
Districts 7, 8, 9

Figure 2

State of Illinois
Department of Transportation

SPECIAL PROVISION
FOR
RUBBLIZING PCC PAVEMENT

Effective June 1, 2001

Description. This work shall consist of rubblizing the existing portland cement concrete (PCC) pavement.

Materials. Aggregate replacement material, for areas of approximately 1 sq m (10 sq ft) or less, shall be a Class D Quality (or better) crushed stone, crushed slag, crushed concrete, or crushed gravel meeting a CA 6 or CA 10 gradation; according to Section 1004 of the Standard Specifications. Bituminous concrete mixture used for repairs shall be the same as noted in the mixture requirements for mainline binder.

Equipment. Equipment shall be according to the following Articles of Section 1100:

Item	Article/Section
(a) Vibratory Steel Wheel Roller..(Note 1)....................................	1101.01
(b) Pneumatic Tired Rollers.........(Note 2)..................................	1101.01

(c) Multi-head Breaker (MHB). The equipment shall consist of a self-contained, self-propelled MHB. Hammer heads shall be mounted laterally in pairs with half the hammers in a forward row, and the remainder diagonally offset in a rear row so there is continuous pavement breaking from side to side. This equipment shall have the capability of rubblizing pavement up to 4 m (13 ft) in width, in a single pass. Hammer drop height shall have the ability to be independently controlled. (Note 3)

(d) Resonant Breaker. The equipment shall consist of a self-contained, self-propelled resonant frequency pavement breaking unit capable of producing low amplitude, 8,880 N (2,000 lb) blows, at a rate of not less than 44 per second.

(e) Z-Pattern Steel Grid Roller. The equipment shall consist of a self-contained, self-propelled vibratory steel wheel roller with a Z-pattern grid cladding bolted transversely to the surface of the drum. The vibratory roller shall have a minimum gross weight of 9 metric tons (10 tons).

Note 1. The vibratory roller shall have a minimum gross weight of 9 metric tons (10 tons).

Note 2. The pneumatic tired rollers shall develop a compression of not less than 50 N/mm (300 lb/in.), nor more than 90 N/mm (500 lb/in.), of width of the tire tread in surface contact.

Note 3. When the MHB is used, a Z-pattern steel grid roller shall be used for additional particle break down as described herein.

CONSTRUCTION REQUIREMENTS

General. If a drainage system is specified on the plans, the system shall be installed and functioning before rubblizing begins. Rubblizing shall commence after removal of any existing bituminous concrete overlay in the area to be rubblized. Any bituminous concrete overlay left on the pavement (after the milling process) shall be removed prior to rubblizing to the satisfaction of the Engineer.

Partial-depth bituminous concrete patches may be left in place and impacted by rubblizing equipment. If breaking is not satisfactory under partial-depth bituminous patches, alternate methods shall be used to break the pavement with approval of the Engineer. Full-depth bituminous patches will be reviewed by the Engineer prior to rubblizing. Unsound patches will be removed and replaced with a Class C or D patch. If the patch is concrete it shall be rubblized. Lane width, full-depth bituminous patches that exceed 3 m (10 ft) in length shall not be impacted by breaking equipment. The Engineer will direct the removal of any unstable material, and method of replacement.

If the unsound patch is greater than 1 sq m (10 sq ft), bituminous concrete binder mixture shall be used. When the road is closed to traffic and the unsound patch is less than or equal to 1 sq m (10 sq ft), the replacement material may be aggregate.

PCC pavement or other PCC appurtenances to remain in place shall be severed from the pavement to be rubblized with a full-depth saw cut. Rubblized pavement less than or equal to 1 sq m (10 sq ft) dislodged by construction traffic shall be repaired with aggregate replacement material and compacted prior to the paving operation. Rubblized pavement greater than 1 sq m (10 sq ft) dislodged by construction traffic shall be repaired with bituminous concrete binder mixture.

The Contractor shall prevent damage to underground utilities and drainage structures during rubblizing. Approved alternate breaking methods shall be used over underground utilities and drainage structures as specified on the plans or directed by the Engineer.

Reinforcement shall be left in place, except that reinforcement projecting from the surface after breaking or compaction shall be cut off below the surface and removed. Any loose joint fillers, expansion material, or other similar items shall also be removed.

Pavement Breaking. Above the reinforcing steel or upper one-half of the pavement, the equipment shall break the pavement such that at least 75 percent of the pieces are a maximum of 75 mm (3 in.). Below the reinforcing steel or in the lower one-half of the pavement, at least 75 percent of the pieces shall be a maximum of 225 mm (9 in.). Concrete to steel bond shall be broken. Uniform breaking shall be maintained through successive passes of the breaking equipment.

Breaking shall be accomplished only by the method(s) specified on the plans and defined as follows:

Method I - This method uses the MHB and Z-pattern steel grid roller to break the pavement, as specified herein.

Method II - This method uses the resonant breaker to break the pavement, as specified herein. This resonant breaker utilizes high flotation tires, which shall be maintained under 415 MPa (60 psi). The breaking shall begin at the centerline and proceed to the edge of the pavement.

Method III - This method uses the resonant breaker to break the pavement, as specified herein, without restriction on tire pressure.

Method IV - This method uses either the MHB with Z-pattern steel grid roller or the resonant breaker to break the pavement, as specified herein.

Prior to the acceptance of the proposed breaking procedure, the Contractor shall complete a strip for evaluation by the Engineer. To ensure the pavement is being broken to the specified dimensions; the Contractor shall excavate a broken area of 1 sq m (10 sq ft), in two separate locations during the first day of breaking, as directed by the Engineer. Modifications to the breaking procedure must be made if the size requirements are not met. These excavations may be repaired with replacement material. If breaking procedures or conditions change, additional excavations to inspect the broken pavement dimensions shall be made, as directed by the Engineer.

Any large concrete pieces that result from inadequate breaking shall be treated as follows:

Size and Location of Pieces	Action
Greater than 225 mm (9 in.) at surface of broken pavement.	Reduce size to under 225 mm (9 in.), or remove and replace.
Greater than 300 mm (12 in.) below steel or lower 1/2 of broken pavement.	Reduce size to under 300 mm (12 in.), or remove and replace.

Unsuitable or unstable material encountered during the breaking process shall be removed and disposed of, according to Article 202.03 of the Standard Specifications. Areas of approximately 1 sq m (10 sq ft) or less may be repaired by use of aggregate replacement material. Larger unstable areas require removal and replacement, as directed by the Engineer. Following subgrade repairs, bituminous concrete binder mixture shall be placed to the depth of the original PCC pavement, and compacted to the satisfaction of the Engineer.

Compaction. Prior to placing the bituminous overlay, the complete width of the broken pavement shall be compacted by vibratory steel wheel and pneumatic tired rollers in the following sequence:

After breaking:

1. Minimum of four passes with Z-pattern steel grid roller (only with the MHB).

2. Four passes with a vibratory roller.

3. Two passes with a pneumatic-tired roller.

The contractor shall not trim the broken or rubblized pavement, or otherwise attempt to grade the broken or rubblized pavement to improve grade lines.

Immediately prior to overlay:

Two passes with a vibratory roller.

Any unstable material encountered while compacting or under construction trafficking shall be treated as defined in the section entitled Pavement Breaking. If a large area of unstable material is identified during the rubblizing process, work shall be halted and the Engineer notified. Any depressions greater than 50 mm (2 in.) in depth shall be filled with replacement material and compacted. When specified by the Engineer, replacement material shall be used to reestablish the pavement crown. Water may be used to aid in compaction of the replacement material, when approved by the Engineer.

Opening Roadway to Traffic. Public traffic will not be allowed on the rubblized pavement before the required binder layers are in place, except at crossovers and/or access points. Public traffic will not be allowed on a rubblized crossover or access point for more than 24 hours. Maintenance of crossovers and/or access points shall be as specified by the Engineer. Crossovers and/or access points shall be maintained in the same compacted state as the other areas, until the bituminous concrete overlay is in place. Construction traffic shall be limited to delivery of materials directly ahead of the paver.

Paving Limitations. A tracked paver shall be used to place the first lift of bituminous concrete binder over the prepared rubblized pavement. During stage construction, the overlay width shall be such that it will not interfere with subsequent rubblizing operations. At a given location, the overlay shall be placed within 48 hours of the pavement breaking operation. If rain occurs between rubblizing and paving, the rubblized pavement shall be dry and stable to the satisfaction of the Engineer before the paving operation begins.

If a material transfer device is proposed, the Contractor shall submit equipment specifications with axle loading configurations and proposed paving sequence to the Engineer three weeks prior to paving. The Engineer will provide any equipment restrictions based on device loadings and proposed paving sequence.

Method of Measurement. Rubblizing will be measured for payment in square meters (square yards) of existing pavement in place.

Basis of Payment. This work will be paid for at the contract unit price per square meters (square yards) for RUBBLIZING PORTLAND CEMENT CONCRETE PAVEMENT, of the method shown in the plans. *(Design Note 1)*

Any required removal of unsuitable or unstable material, subgrade repair, and bituminous concrete placement will be paid for according to Article 109.04 of the Standard Specifications.

Action taken to address any large concrete pieces resulting from inadequate breaking will not be paid for separately.

(Design Note 1. The method of pavement breaking must be selected.)

Illinois Department of Transportation
2300 South Dirksen Parkway / Springfield, Illinois / 62764

Subject:
Rubblizing PCC Pavement and Placing a Bituminous Concrete Overlay

CONSTRUCTION MEMORANDUM NO. 01-40

Effective: **June 1, 2001**

Expires: **Indefinite**

Rubblizing is a rehabilitation process in which the existing portland cement concrete (PCC) pavement is fractured (in-place) into small pieces, and the concrete/steel bond is broken. The pavement is compacted to create a uniform base. The purpose of this memorandum is to advise the Resident on the equipment, construction sequence, and other considerations involved in rubblizing a PCC pavement and placing a bituminous concrete overlay.

Equipment

Three types of PCC pavement breakers can be used to rubblize the pavement: a multi-head breaker, and two versions of a resonant breaker. The multi-head breaker uses a series of drop hammers to impact the pavement in a specific pattern. Pavement breaking occurs at the back of the machine. Full-lane coverage can be achieved in a single pass.

The resonant breakers produce a high-frequency, low amplitude striking force to a shoe that breaks the pavement but does not damage the underlying layers. The 27 metric ton (30+ ton) resonant breaker requires up to 20 passes per 3.6 m (12 ft) lane to cover the pavement area. The resonant breaker in Rubblization Method II utilizes a high flotation tire, with a tire pressure under 4l5 MPa (60 psi) for use with softer subgrades.

Choice of rubblizing equipment is project dependent. The project special provisions will indicate the Rubblization Method (I, II, III or IV- per the Special Provision for Rubblizing PCC Pavement) that is applicable.

Construction Sequence

The general sequence of construction should be as follows:

- Install underdrains or French drains, as required.
- Remove any existing bituminous concrete overlay to the staged width.
- Remove and replace any existing unsound bituminous repair materials.
- Rubblize the pavement.
- Compact the broken pavement.
- Pave the binder lifts of the bituminous concrete overlay.

- Allow traffic on sections which have adequate thickness, as shown on the plans (if needed).
- Pave the surface of the bituminous concrete overlay.

Other Construction Considerations

Bituminous material from temporary patching, in the pavement section may be left in place. If there are any full-depth bituminous concrete patches in the section, soundness of the patch material should be determined. Visually indeterminate patches may be investigated, with a limited coring program. If a bituminous concrete patch is considered unsound, the material should be removed. When traffic is maintained during the patching operation, the replacement material should be a Class C or D patch. If concrete is the replacement material it shall be rubblized.

If the unsound patch is greater than 1 sq m (10 sq ft), bituminous concrete binder mixture shall be used. When the road is closed to traffic and the unsound patch is less than or equal to 1 sq m (10 sq ft), the replacement material may be aggregate. Aggregate replacement material shall be a Class D Quality (or better) crushed stone, crushed slag, crushed concrete, or crushed gravel meeting a CA 6 or CA 10 gradation; according to Section 1004 of the Standard Specifications.

Partial-depth bituminous concrete patches may be left in place during rubblization. If partial-depth patches prevent proper breaking of the PCC pavement, a skid steer loader (with a jack hammer attachment or similar device) may be used to complete breaking in these areas.

Any large concrete pieces that result from inadequate breaking can be broken as described above or can be removed along with any unsuitable and unstable material encountered during the breaking process. Removed material shall be disposed of according to Article 202.03 of the Standard Specifications. Areas of approximately 1 sq m (10 sq ft) or less may be repaired by use of aggregate replacement material. Larger unstable areas require removal and replacement as directed by the Engineer. The Department's "Subgrade Stability Manual" will be referenced for subgrade repair, to provide a stable subgrade. Following subgrade repairs, bituminous concrete binder mixture shall be placed to the depth of the original PCC pavement, and compacted to the satisfaction of the Engineer.

The rubblizing process will increase the pavement width 25 to 75 mm (1 to 3 in.) per 2-lane width, and encroach slightly into the underdrain trench. This has not caused performance problems with sand trench and pipe type underdrains to date. When using the Resonant Breaker, the breaking shall begin at the centerline and proceed to the outside edge of the pavement. Also, when using the Resonant Breaker, the driving of heavy wheel loads directly over the underdrain trench should be avoided as much as possible. This may require limiting the breaking operation to only one direction, until the breaker wheels are no longer aligned with the trench. Wheel loads directly over the underdrain trench are of less concern if the existing shoulder is in sound condition. Regardless of the method chosen, the contractor is responsible for protection of the pipe underdrains along the project.

Rubblized pavement should be covered with the overlay as quickly as is practical. Light rains have little effect. Underdrains will minimize the adverse effects of rainfall.

No traffic (including unnecessary construction traffic) should be allowed on the fractured pavement surface once the breaking operation begins. Traffic will dislodge the rubblized base, negatively affect grade control, and loosen the interlock between pieces. This will reduce the support of the layer. Traffic on the rubblized base may result in subgrade intrusion, requiring complete removal and replacement of the rubblized base.

All bituminous concrete binder lifts should be paved before traffic is allowed onto the section. Sections opened with reduced thickness have the potential of becoming overstressed very rapidly, which results in reduced pavement life.

If a Contractor proposes the use of a Material Transfer Device (MTD), the Contractor is required to submit equipment specifications with axle loading configurations to the Engineer three weeks prior to paving. The Engineer will contact the Bureau of Materials and Physical Research to perform an analysis and provide any equipment restrictions based on device loadings and proposed paving sequence.

Gary D. Gould, P.E. Engineer of Construction	Eric E. Harm, P.E. Engineer of Materials & Physical Research