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AN EVALUATION OF THORMA JOINT

A FLEXIBLE BRIDGE EXPANSION JOINT SYSTEM

Construction Report

By
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and
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16. Abstract

The Thorma-Joint is a flexible bridge expansion joint system composed of a rubber asphalt binder and stone aggregate. The Thorma-Joint is used on bridge decks which are resurfaced with a bituminous concrete overlay. This system is purportedly strong enough to withstand traffic loads and environmental stresses, and is flexible enough to expand and contract with the bridge joint without cracking.

The Thorma-Joint system was experimentally installed on six bridges. An evaluation conducted at two months and after a year of exposure indicated that the Thorma-Joint prevented surface water from infiltrating into the deck joints. The overall condition of the Thorma-Joint was, however, found to be marginally satisfactory. The workmanship was of poor quality and at some of the joints the rubber asphalt surface layer developed some shoving, spalling, and ravelling. Additional Thorma-Joints will be installed for further evaluation.

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1. OBJECTIVE

The objective of this study was to evaluate the field performance of the Thorma-Joint flexible bridge expansion joint system installed on Route 3, Section 2J in the City of Clifton, Passaic County, New Jersey.

2. BACKGROUND

Many State and local highways are rehabilitated by means of resurfacing with a bituminous concrete overlay. Concrete bridge decks located within the project are usually also resurfaced at the same time. The resurfacing of the bridge decks presents a problem because the expansion joints are covered by the asphalt overlay. The relatively inflexible asphalt overlay is prone to cracking and deterioration at the expansion joints during normal contraction and expansion of the bridge deck (Figure 1). Joint failure is then further accelerated by traffic loads, freeze-thaw, thermal expansion, and passage of of snow plow blades over the uneven joint area. Consequently surface water enters the joint and causes damage to the steel or concrete superstructure and bearings.

A number of proprietary joint systems have been developed to deal with this problem. One such system is the Thorma-Joint. The Thorma-Joint consists of a rubber asphalt binder and stone aggregate mixture. Installation requires the removal of an 18 inch wide section of the bituminous overlay over the joint and replacing it with the Thorma-Joint asphalt binder and stone agregate mixture to act as a riding surface and a waterproof flexible joint system (Figure 2).

In July, 1988, the Thorma-Joint system was installed on six (6) bridges during the resurfacing of Route 3, Section 2J, in the City of Clifton, Passaic County, New Jersey. The installation was monitored during construction by the Resident Engineer and the Thorma-Joint performance was evaluated by the Division of Research and Development at two months and after a year of service.

3. PRELIMINARY INVESTIGATION

Plans, specifications, and cost estimates for the resurfacing of Route 3, Section 2J were developed by the New Jersey Department of Transportation, Division of Design. The Thorma-Joint specifications are presented in Appendix A. The contract was awarded to Pressure Concrete Surfaces. The Thorma-Joint subcontractor was Linear Dynamics, Inc. of Parsippany, NJ. Construc-

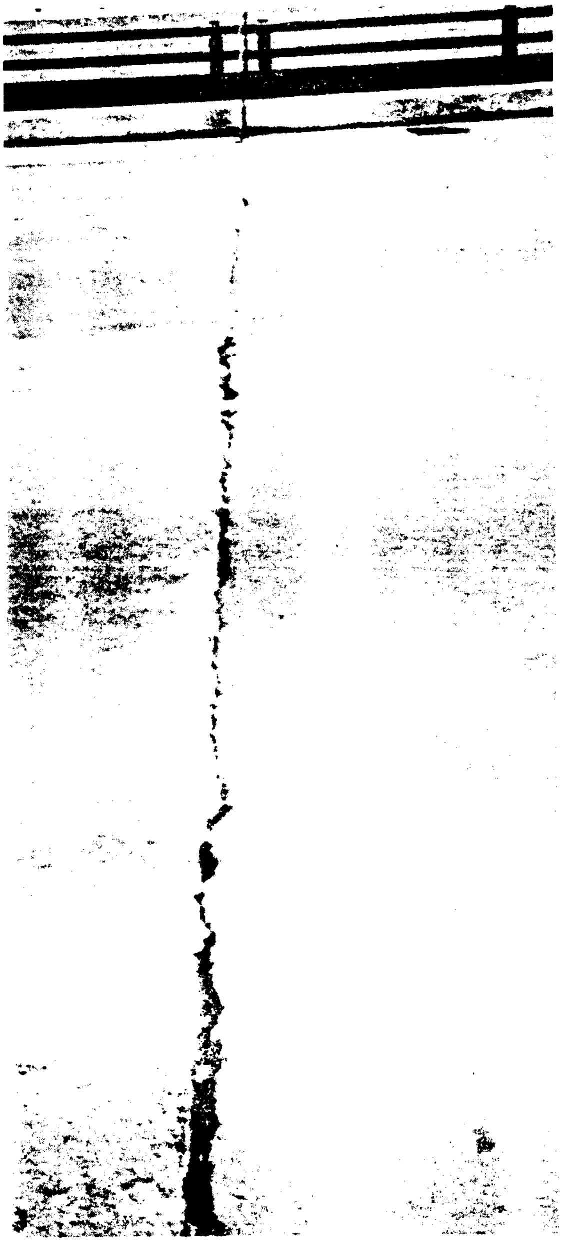
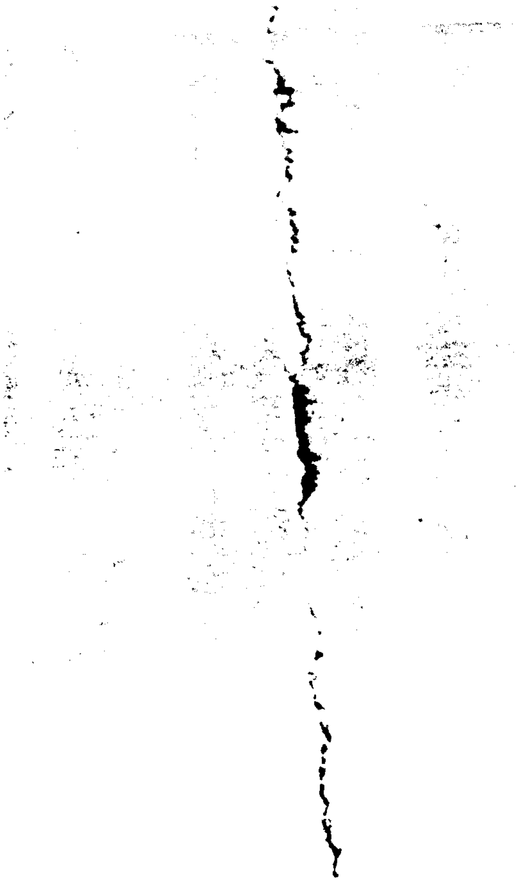
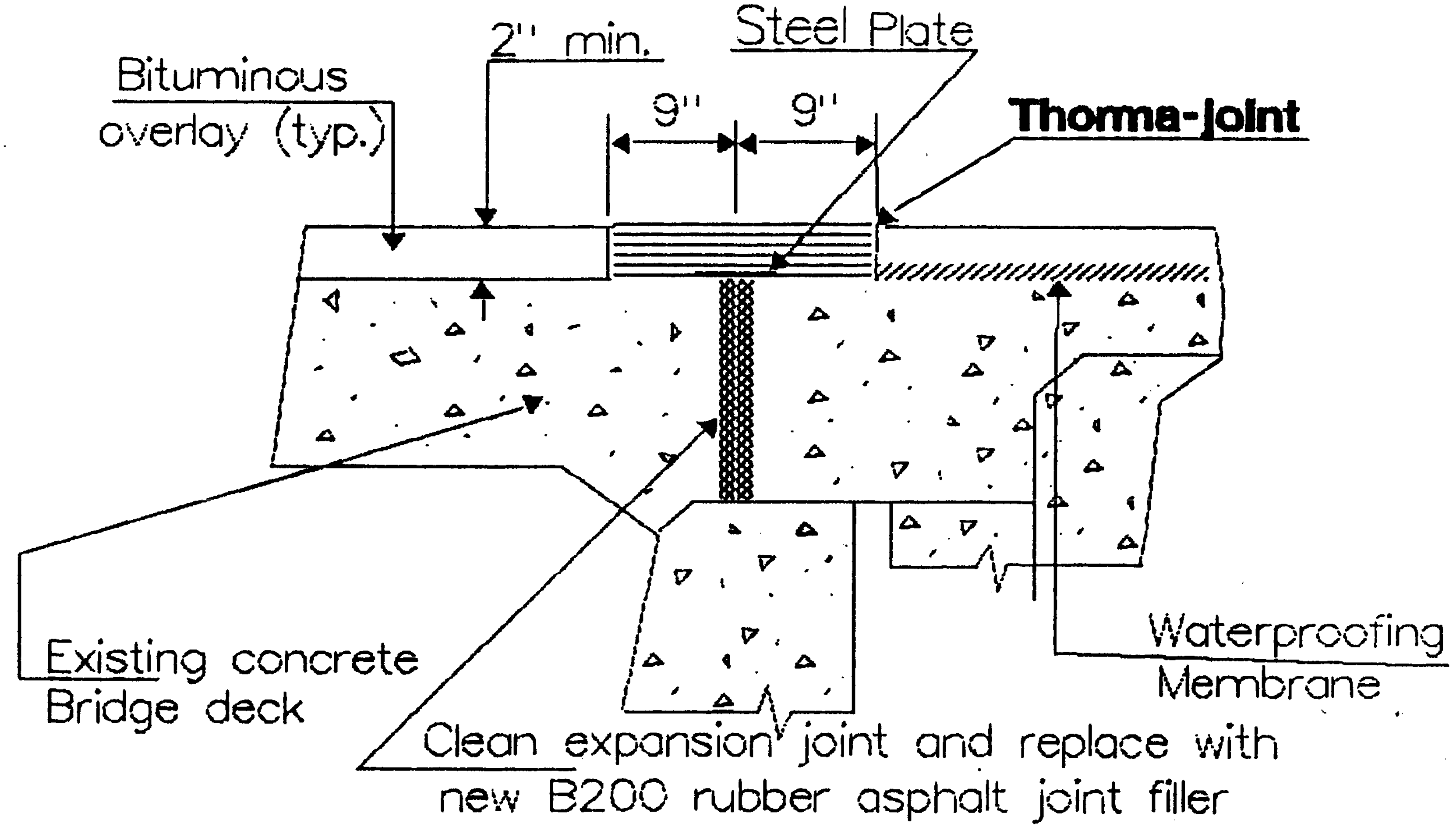


Figure 1. Typical Reflection Cracking at Bridge Deck Expansion Joints.





TYPICAL SECTION THORMA-JOINT
Figure 2

tion started in April, 1988. The Thorma-Joints were installed during July, 1988. The contract completion date was September 1, 1988.

A. Location and Project Description

1. Route 3 (1953), Section 2J

Resurfacing - West of Broad Street to east of Main Avenue
City of Clifton, Passaic County

2. Scope of Construction Project

Beginning of Project: Federal Project No. NJ-HES-54 (140) Route 3, Sta. 63+74, MP 1.08

End of Project: Route 3, Sta. 219+75, MP 4.03

Project Length: 2.95 mi.

NJDOT Control Section: C.S. 1601

Federal Aid Route Number: F.A.P. 54 (Urban)

3. Site Description

Route 3 is a main east-west arterial highway that carries traffic from highly urbanized northern New Jersey to the Lincoln Tunnel and New York City (Figure 3). Route 3 in the project area is a six lane divided highway with limited access. During the subject project, the existing jointed reinforced concrete pavement was resurfaced with at least 2-in of bituminous concrete. Six (6) bridges were resurfaced during the project (Figure 4). The Thorma-Joint system was installed over the expansion joints of the 6 bridges in accordance with the manufacturer's specifications.

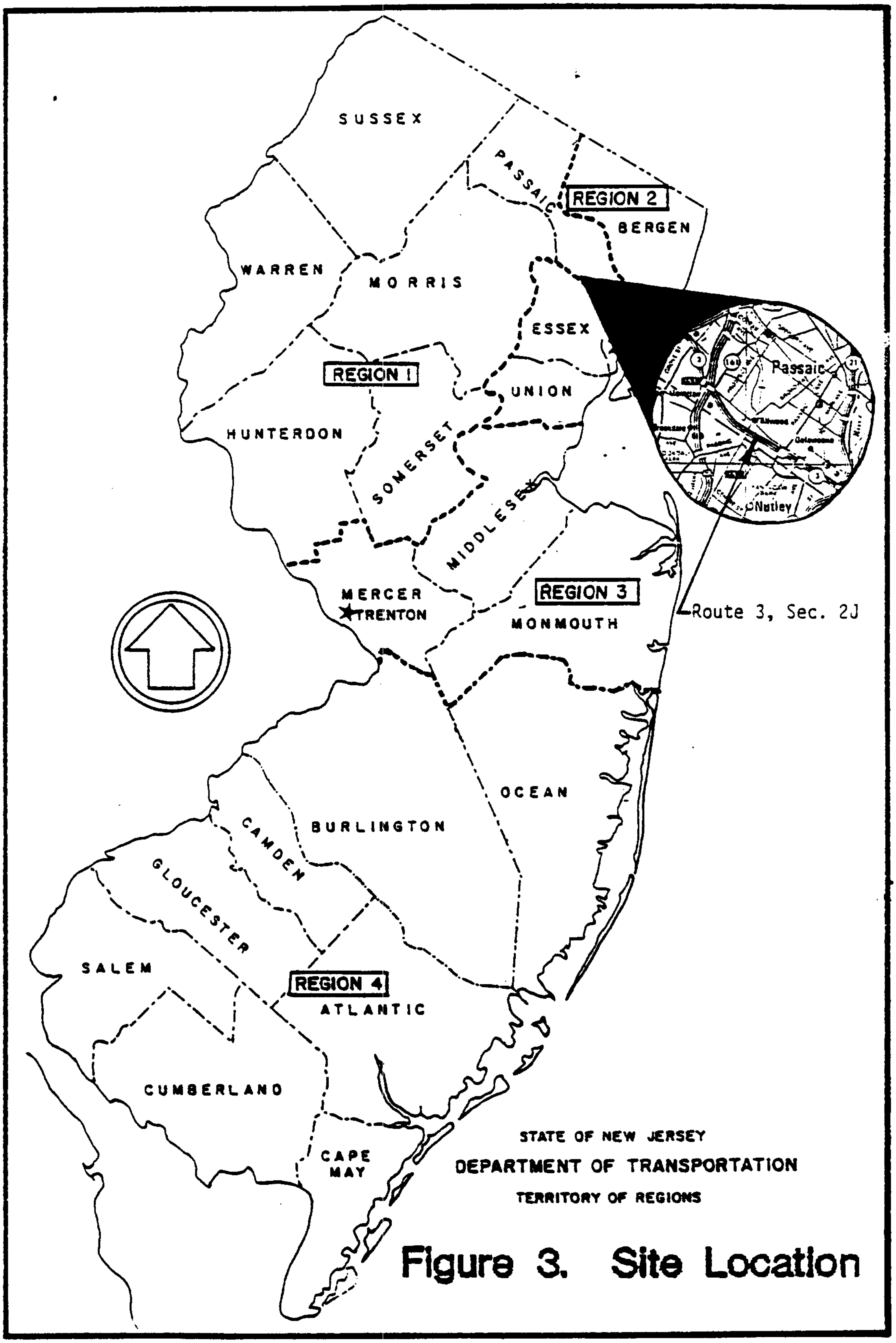


Figure 3. Site Location

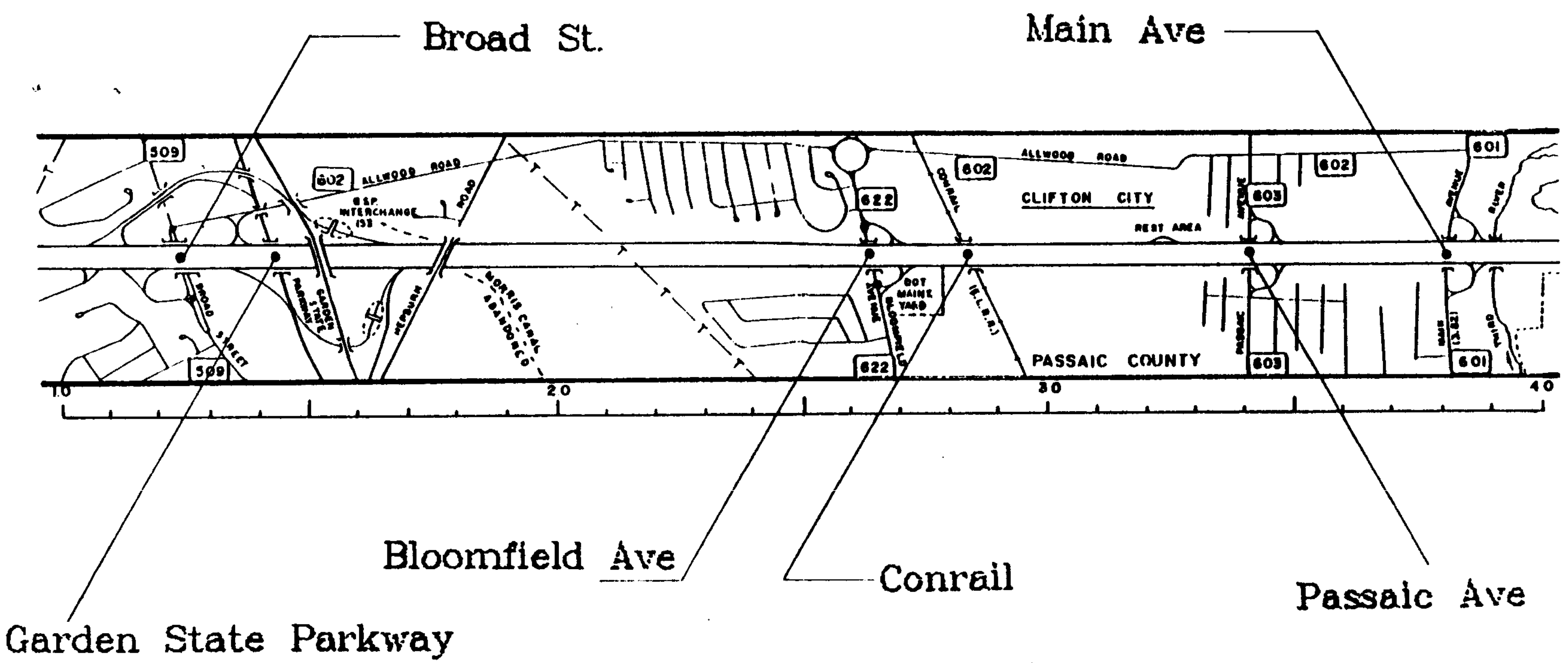


Figure 4. Route 3, Section 2J, Bridge Location

Table 1. Location of Thorma-Joints

	Bridge Location	NJDOT Bridge No.	MP	Length of Thorma-Joint (LF) EB	WB	Total
1.	Broad St.	151	1.25	125	125	250
2.	G. S. Pkwy	---	1.45	245	245	490
3.	Bloomfield Ave.	153	2.60	110	110	490
4.	Conrail	154	2.80	90	90	180
5.	Passaic Avenue	155	3.40	85	85	170
6.	Main Ave.	156	3.8	85	85	170
						Total = 1480

Contract bid price = $ 110.00 per LF
Cost for Thorma-Joint = 1460 x $110.00 = $163,000
Total cost for resurfacing =$ 4,820,000

Thorma-Joint = $163,000/$4,820,000 = 3.4% of total cost

4. Design Traffic Data

1985 AADT (2 way) - 124,200
1996 AADT - 127,720
% Trucks - 4.0%
Speed - 55 mph.

B. Pre-construction Condition of Roadway

A pre-construction survey of the 6 bridges along Route 3 was conducted on January 5, 1988. The weather was overcast and the air temperature was 17 deg. F. The bridge deck joints were expanded at maximum width due to the cold temperatures. Joint openings ranged from 1-in to 2-in wide. The non-armored expansion joints were spalled and in poor condition. Armored expansion joints were in good condition. The concrete bridge decks exhibited severe spalls and potholes and certainly required resurfacing (Figure 5).

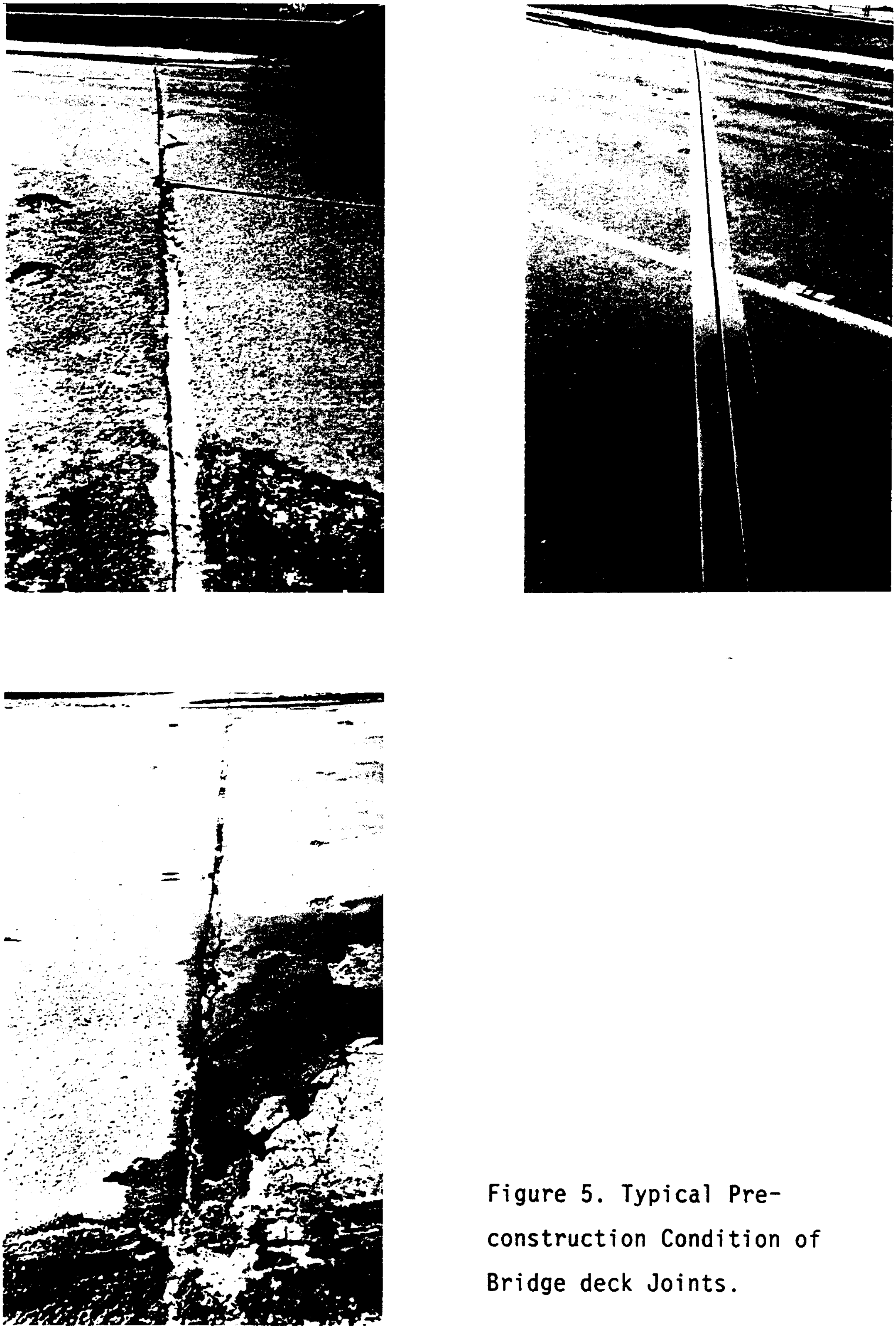


Figure 5. Typical Pre-construction Condition of Bridge deck Joints.

4. THORMA-JOINT CONSTRUCTION

During July 1988, the Thorma-Joints were installed along Route 3, Sec. 2J by Linear Dynamics, Inc of Parsippany, New Jersey. Due to the high traffic levels (in excess of 120,000 vehicles per day), the resurfacing and Thorma-Joint installation was done at night. Figure 6 shows the intermediate phases of construction. The Thorma-Joint installation was conducted in accordance with the manufacturer's recommended procedures:

Thorma-Joint Installation Method

1. Mark out and sawcut through the full depth of bituminous concrete surfacing. Sawcuts shall be marked 9-in on either side and parallel to the deck expansion joint. Do not sawcut into concrete bridge deck.

2. Break out bituminous concrete from within 18-in wide area and remove the material.

3. Clean all concrete surfaces with a hot, compressed air lance until a clean, dry surface is produced. Remove all water and cutting dust.

4. Seal the expansion joint gap with hot B200 rubber asphalt binder. Span the spalled non-armored joint edges with an aluminum plate which is nailed to the rubber asphalt joint filler. Armored joints shall be spanned with a 1/16-in steel plate.

5. Coat or "tank" the horizontal and vertical surfaces of the cut joint with hot B200. The tanking shall be continuous and adhere to all vertical surfaces. On the bottom of the joint cavity, the B200 binder shall be up to 1/4-in thick.

6. Rotate the trap rock aggregate (3/8-in stone) in a perforated drum to shake off all dust and moisture. Rotation shall continue until the stone temperature is raised to the working range of 230 to 350 deg. F.

7. Place the hot aggregate in the 2-in deep trench in layers not to exceed 1-in thick. Level the first stone layer level by raking prior to application of binder.

8. Pour B200 rubber asphalt binder over the first stone layer. Coat each stone and fill the voids while avoiding an excess of binder. Mix the stone and binder together in the trench by rak-

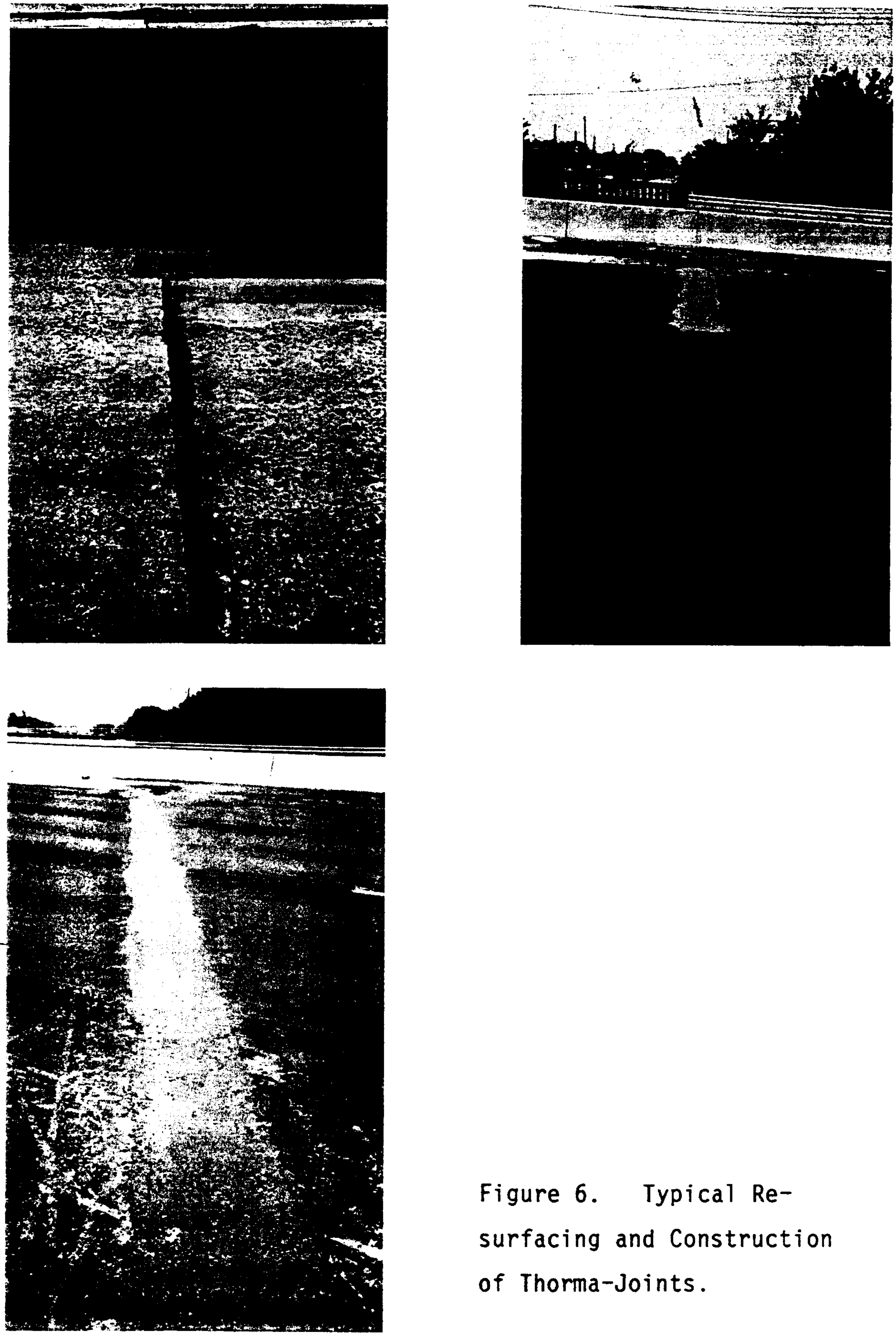


Figure 6. Typical Resurfacing and Construction of Thorma-Joints.

ing in-situ.

9. Overfill the top of the joint with a topping of stone rich mix consisting of a ratio of 6:1 by weight of stone to binder. When the mixture has cooled to 160 deg. F., compact the Thorma-Joint with a vibratory drum roller.

10. Apply additional B200 binder to the joint surface after compaction. Screed the binder over the surface to fill voids.

5. POST-CONSTRUCTION EVALUATION

In September, 1988, about 2 months after installation of the Thorma-Joint, a post-construction evaluation was conducted. The Thorma-joints were in fair to average condition (Figure 7). The rubber asphalt surface exhibited no signs of cracking. The visual inspection of the underside of the bridge decks indicated that that there was no deck joint leakage and that the Thorma-joints seem to provide an impermeable and waterproof barrier to joint infiltration.

The overall appearance of the completed Thorma-joints was, however, less than desirable. Most of the Thorma-joints were not compacted flush with the surrounding overlay and a slight hump was left which caused noticeable traffic noise as vehicles passed over. At some locations, the Thorma-joints were rutting, shoving, and delaminated. This could be attributed to the record breaking hot temperatures (20 days over 90 deg F during July, 1988) and the passage of frequent and heavy traffic (AADT, 2 way = 124,000 vpd). There is some concern that the rubber asphalt B200 binder may not have the necessary stability to withstand the high summer temperatures in New Jersey.

6. ONE YEAR INSPECTION

A 1 year inspection of the Thorma-Joints was conducted in August, 1989. The visual inspection indicated that the overall condition of the Thorma-Joints has improved slghtly since construction due to compaction under traffic. The rutting of the joint surface has stabilized and not increased since the two month inspection. Inspection of the underside of the bridge decks indicated that the Thorma-Joints are preventing leakage through the expansion joints.

Even though the Thorma-Joints appear to be impermeable to water infiltration, the overalll appearance of the joints, after one year of service, is still marginally satisfactory. The less than desirable workmanship in screeding and compacting the surface may have contributed to the ravelling, rutting, and shoving

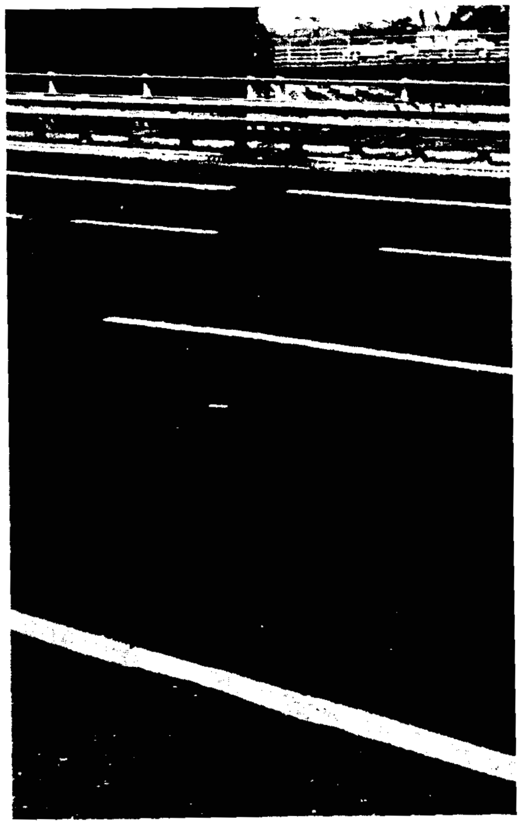
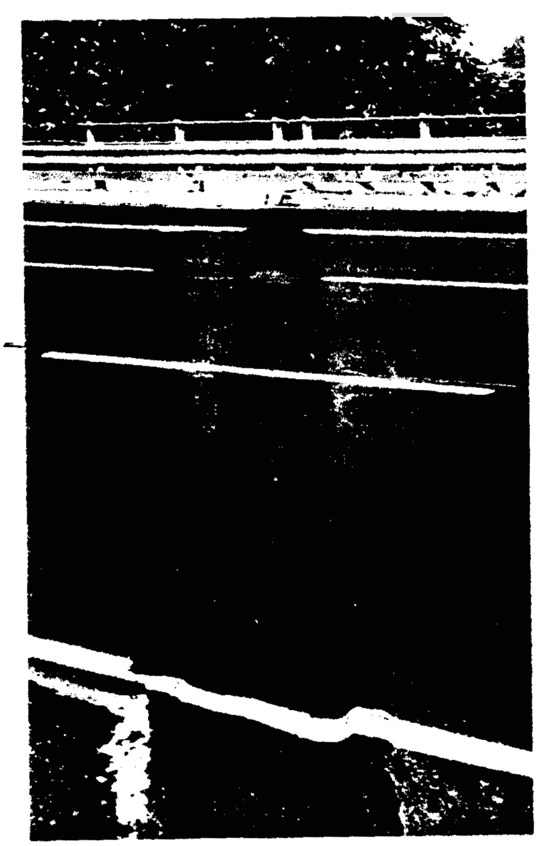
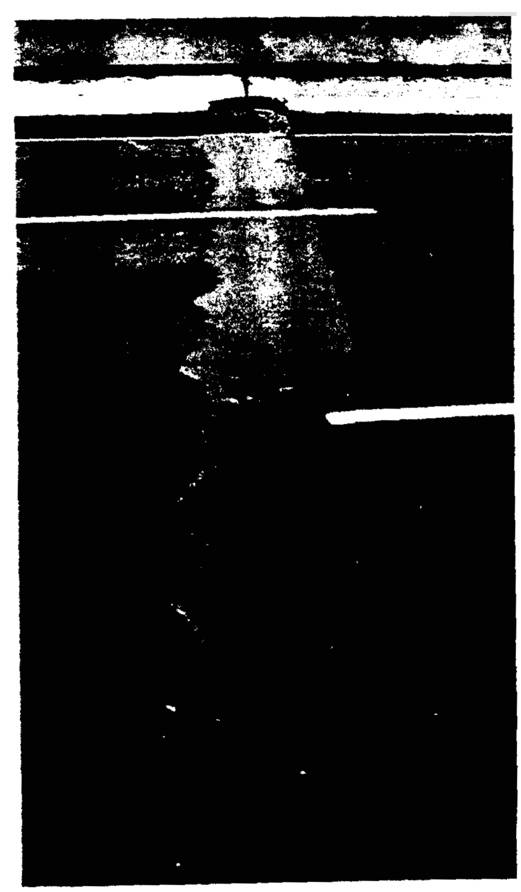


Figure 7. Typical Two-month Condition of the Thorma-Joints.





that is evidenced. Some of the problems may also have been aggravated by the high temperatures experienced during the summer months and the heavy traffic of Route 3. Figure 8 shows the typical condition of the Thorma-Joints after one year of service.

7. ECONOMICS

Regardless of it's appearance, the joint system is relatively expensive at a cost of $ 110.0 per LF.

Thorma-Joint bid price	= $ 110.00 per LF
Contract Quantity	= 1480 LF
Total Thorma-Joint Cost	= $163,000
Route 3, Section 2J resurfacing cost	= $4,829,000

Thorma-Joint cost = $163,000/$4,829,000 = 3.3% of the resurfacing cost

The high cost of the Thorma-Joint is attributed to the saw cutting operation and the labor intensive placement of the asphalt mixture. In addition, the proprietary joint also requires a very costly rubber asphalt binder to cover the 18-in wide trench. An 18-in wide joint substantially increases the cost of the Thorma-Joint and may also allow for rutting and shoving to develop. Reducing the width of the Thorma-Joint will decrease the quantity of material used and hence result in lower overall costs. Perhaps an 8-in or 12-in wide Thorma-Joint may be adequate to substantially reduce the substantial material costs and also diminish the potential for rutting and shoving.

For structures with relatively small movements, 1/2-in to 3/4-in, an alternate solution to the 18-in wide Thorma-Joint may be to simply "saw and seal" the bituminous concrete overlay over the bridge deck expansion joints. The saw and seal technique is commonly used to prevent reflective cracking of asphalt overlays over transverse and longitudunal joints of reinforced concrete pavements (Figure 9). It seems possible that a modified version of the saw and seal might be able to accomodate movement of the bridge deck joint in a manner similar to the successful approach used on concrete pavements. The saw and seal consists of a single saw cut immediately over the joint. The saw cut is filled with rubber asphalt joint sealer. The price of saw and seal is

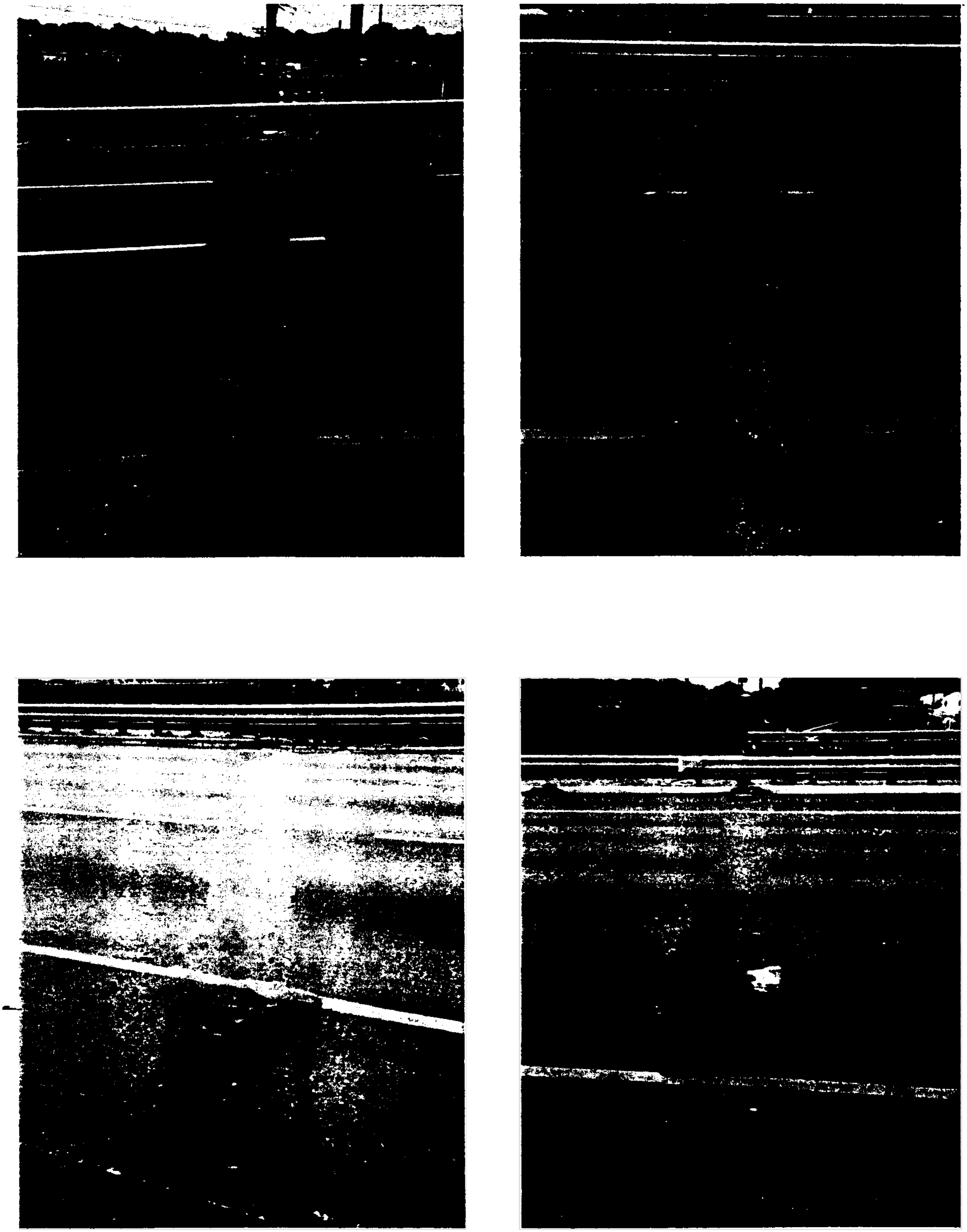


Figure 8. Typical One-Year Condition of the Thorma-Joints.

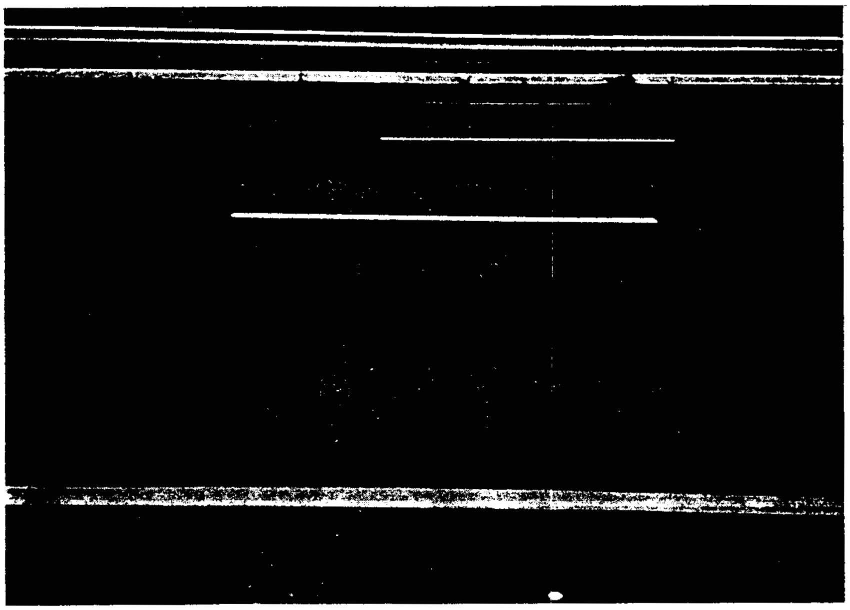


Figure 9. "Saw and seal" Joint System.

around $ 3.00 per LF. This could be a significant cost savings when compared to the $ 110.00 per LF cost of the Thorma-Joint.

8. SUMMARY

In spite of the rutting, shoving, ravelling, and spalling, and the unsatisfactory appearance, the Thorma-Joints have remained watertight and has prevented infiltration of water into the bridge deck joints. There is some concern that the B200 rubber asphalt binder may not have the necessary stability to withstand New Jersey's hot summer temperatures. An inspection of Thorma-Joints that have been installed on the Garden State Parkway (Appendix B) for at least 2 to 3 years show no signs of leakage and appeared to be flush with the pavement surface. Based on this favorable performance, additional Thorma-Joints will be constructed on an adjacent section of Route 3, Section 2L which is anticipated to be resurfaced in the Summer of 1990.

However, as discussed previously, a less expensive alternative to using the Thorma-Joint may be to "saw and seal" the overlay immediately over the expansion joint. The saw and seal should accomodate vertical and horizontal movement of the bridge deck without cracking thus limiting infiltration. At a cost of $ 3.00 per LF, the saw and seal technique can be cost effective alternative to the $110.00 per LF Thorma-Joint system.

9. RECOMMENDATIONS

Based on the 1 year evaluation of Route 3, Section 2J and the inspection of Thorma-Joints installed on the Garden State Parkway, it is recommended that:

1. Additional evaluation of Thorma-Joints on Route 3, section 2J, be conducted in the Summers of 1990 and 1991.
2. Additional Thorma-Joint be installed on Route 3, section 2L. These joints should then be evaluated after a year of service (Summer of 1991).
3. The "Saw and seal" technique should be investigated for application on bridge decks with relatively small movements, such as 1/2 to 3/4 inches.

Until problems with the undesirable appearance (rutting, ravelling, and shoving) of the Thorma-Joints are satisfactorly resolved, standard use of the Thorma-Joint is not recommended.

APPENDIX A

THORMA-JOINT SPECIFICATIONS

ROUTE 3, SECTION 2J

SECTION 501 - CONCRETE STRUCTURES

501.01 DESCRIPTION

THE SECOND PARAGRAPH IS CHANGED TO:

MATERIALS AND METHODS OF CONSTRUCTION NOT SPECIFICALLY COVERED IN THE PLANS AND SPECIFICATIONS SHALL CONFORM TO THE 1983 AASHTO STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES.

501.08 REINFORCEMENT STEEL.

(B) PROTECTION OF MATERIALS.

THE FOLLOWING IS ADDED:

WHEN EPOXY-COATED REINFORCING STEEL BARS ARE CUT IN THE FIELD, THE ENDS OF THE BARS SHALL BE COATED WITH THE SAME MATERIAL USED FOR REPAIR OF COATING DAMAGE. REPAIR OF EPOXY COATING SHALL BE IN ACCORDANCE WITH AASHTO M284-81.

(D) PLACING AND FASTENING.

THE FOLLOWING IS ADDED:

BAR SUPPORTS AND WIRE TIES FOR EPOXY COATED REINFORCEMENT SHALL BE PLASTIC OR EPOXY COATED.

501.24 OPENING TO TRAFFIC.

THE THIRD PARAGRAPH IS CHANGED TO:

CLASS A CONCRETE MAY BE USED AS A CLASS A-1 HIGH-EARLY STRENGTH CONCRETE PROVIDING THE MIX DESIGN MEETS THE CRITERIA SPECIFIED IN SECTION 914. WHEN CLASS A CONCRETE HAS BEEN ACCEPTED AS A CLASS A-1 HIGH-EARLY CONCRETE, AND IS USED FOR DECK SLABS, TRAFFIC AND CONSTRUCTION EQUIPMENT NOT EXCEEDING THE LEGAL LOAD LIMIT MAY BE PERMITTED WHEN THE MINIMUM STENGTH FOR INDIVIDUAL TESTS AS DEFINED IN SECTION 914 EXCEEDS 3,000 PSI FROM FOUR ADDITIONAL CYLINDERS CAST DURING PLACEMENT AND IS NOT LESS THAN SEVEN CURING DAYS OLD.

501.27 INSTALL THORMA-JOINT.

A. DESCRIPTION.

THIS WORK SHALL CONSIST OF SAWCUTTING AND REMOVING A SECTION OF ASPHALT AND INSTALLING A FLEXIBLE EXPANSION JOINT ON EXISTING BRIDGE DECKS AS INDICATED ON THE CONSTRUCTION PLANS.

B. MATERIALS.

AGGREGATE - THE SINGLE SIZED AGGREGATE SHALL BE CHOSEN FROM THE BASALT, GABBOR OF GRANITE GROUPS LISTED IN BS: 812.

BINDER - A BITUMEN BINDER KNOWN AS BJ200, DESIGNED FOR USE IN THORMA-JOINT SHALL BE USED.

C. CONSTRUCTION REQUIREMENTS.

SAWS SHALL BE SET TO CUT THE FULL DEPTH OF THE SURFACING, AND DECK WATER-PROOFING LAYER. CARE SHOULD BE TAKEN NOT TO SAWCUT INTO THE CONCRETE DECK. THE ASPHALT AND WATER-PROOFING LAYER BETWEEN SAW CUTS SHALL BE BROKEN OUT.

AFTER CUTTING AND BREAKING OUT ALL THE MATERIALS BETWEEN THE SAW CUTS TO CONCRETE DECK LEVEL, THE MATERIALS WILL BE REMOVED. ALL CONCRETE SURFACES WILL THEN BE CLEANED BY THE USE OF A HOT COMPRESSED AIR LANCE UNTIL A CLEAN, DRY SURFACE IS PRODUCED. THE CUT ASPHALT WILL BE CLEARED IN A SIMILAR MANNER TAKING CARE TO REMOVE ALL WATER AND CUTTING DUST. IF THERE IS AN INTERRUPTION DUE TO WEATHER OR OTHER CAUSES, THE OPERATION WILL BE REPEATED WITH THE HCA LANCE IMMEDIATELY BEFORE THE TANKING OPERATION.

THE JOINT GAP IS TO BE SEALED AND A METAL PLATE LOCATED ALONG IT. A VERY NARROW GAP SHALL BE SEALED SIMPLY BY POURING HOT BJ200 INTO THE GAP.

A. CAULKING - CAULKING WILL BE INSTALLED SO AS TO BE BETWEEN 5 MM AND 30 MM BELOW THE TOP OF THE DECK ARRISES ON, THE LOWER AREA IN THE CASE OF HEIGHT DIFFERENCE. THIS REFERENCE FOR HEIGHT APPLIES TO THE CLEAN EDGE OR THE SPALLED EDGE. WHICHEVER IS LOWER.

B. JOINT GAP SEALING - AFTER CAULKING THE JOINT GAP WILL BE FILLED WITH HOT BJ200.

C. BRIDGE PLATE INSTALLATION - SPALLED EDGES MUST BE SPANNED BY THE PLATE AND THE PLATE MUST EXTEND BEYOND THE SPALLED AREAS. WHERE THERE IS A HEIGHT DIFFERENCE BETWEEN THE CONCRETE MEMBERS, THE STEEL PLATE SHOULD BE

PREFORMED TO LIE FLAT ON EACH MEMBER BUT SPAN THE GAP, IF NECESSARY, BY FORMING THE DOWNFACE OF ONE AREA TO REACH THE LEVEL OF THE LOWER MEMBER..

HOT BJ200 SHALL BE POURED OVER THE FLOOR AREA OF THE JOINT AND SPREAD TO COAT ALL EXPOSED SURFACES BOTH VERTICAL AND HORIZONTAL. THE TANKING SHALL BE CONTINUOUS AND ADHERE TO VERTICAL SURFACES. ON THE BOTTOM OF THE JOINT CAVITY THE BINDER SHALL BE UP TO 1 CM THICK WITH POOLS OF GREATER THICKNESS WHERE THERE ARE SURFACE IRREGULARITIES.

AGGREGATE SHALL BE ROTATED IN A PERFORATED DRUM TO SHAKE OFF DUST AND ALL MOISTURE. THIS PROCESS SHALL CONTINUE UNTIL THE TEMPERATURE OF THE STONES IS RAISED TO THE WORKING RANGE OF 110 DEGREES TO 180 DEGREES CENTIGRADE.

THE MINIMUM AGGREGATE CONTENT BY WEIGHT SHALL BE 68%. THE HOT AGGREGATE SHALL BE PLACED IN THE JOINT TRENCH IN LAYERS NOT LESS THAN 20 MM AND NOT MORE THAN 40 MM THICK. WHERE THE JOINT THICKNESS OVERALL HAS TO VARY ACROSS THE HIGHWAY A SHORT LAYER OR SUCCESSIVELY SHORTER LAYERS SHALL BE INSTALLED FOR THIS DEPTH VARIATION. THE AGGREGATE SHALL BE RAKED LEVEL IN THE TRENCH BEFORE APPLICATION OF BINDER.

BJ200 IS POURED AND SPREAD OVER EACH STONE LAYER. THE OBJECTIVE IS TO COAT EACH STONE AND TO FILL THE VOIDS BETWEEN WHILE AVOIDING AN EXCESS OF BINDER.

IN PREPARING THE TOPPING LAYER THE RATIO OF AGGREGATE TO BINDER SHALL BE APPROXIMATELY 6:1 BY WEIGHT.

THE COATING OF THE AGGREGATE BY BINDER MAY BE ACHIEVED BY RAKING IN SITU IN THE TOP LAYER OF THE JOINT TRENCH OR BY SEPARATE MIXING ON A ROTATING DRUM MIXER.

THE TOP OF THE JOINT SHALL BE SLIGHTLY OVERFILLED WITH A LEAN MIXTURE AND COMPACTED TO THE PLANE OF THE JOINT SURFACE.

SUFFICIENT BINDER SHALL, IMMEDIATELY AFTER COMPLETION OF COMPACTION, BE SCREEDED OVER THE JOINT TO FILL THE SURFACE VOIDS AND JUST COAT THE SURFACE STONES.

D. METHOD OF MEASUREMENT.

INSTALL THORMA-JOINT WILL BE MEASURED BY THE LINEAR FOOT.

E. BASIS OF PAYMENT.

PAYMENT WILL BE MADE UNDER:

PAY ITEM	PAY UNIT
INSTALL THORMA-JOINT	LINEAR FOOT

APPENDIX B

THORMA-JOINT INSPECTION

GARDEN STATE PARKWAY

Form AD-40 5/77

NEW JERSEY DEPARTMENT OF TRANSPORTATION

MEMORANDUM

TO MEMO OF RECORD

FROM J. Kauffman

SUBJECT Thorma-Joint Field Inspection
Garden State Parkway, Southbound

DATE 10/11/88

TELEPHONE NO. 5-2995

Inspection

Thorma Joint was installed on numerous bridges along Garden State Parkway about 2 to 3 years ago. These bridges were overlaid with bituminous concrete during resurfacing projects. Thorma Joints were installed at expansion joints of the overlaid bridge decks.

Inspection of the bridges indicates that the Thorma Joint has performed well after 2 to 3 years under traffic. The hot poured rubber asphalt surface has remained resilient and waterproof. Informal tests in the field indicate that the rubber asphalt will stretch about 1½" to 2" before breaking apart. This indicates that the Thorma Joint will accommodate up to 2" of joint movement before ripping apart. Inspection of the underside of the bridges shows no evidence of salt staining or water spots that would indicate leakage of the Thorma Joint.

The passage of traffic has compacted the Thorma Joint so that the material is flush with the adjacent pavement. The Thorma Joint does cause an audible increase in traffic noise, however, the increse is not significant when compared to the overall high noise levels of Parkway traffic.

Surveys of several overlaid bridge decks without Thorma Joints indicate that the bituminous concrete overlay exhibits 1/8" to 1/2" wide cracks along the expansion joints. The Thorma Joint does prevent these cracks. However, a simpler, less expensive approach may be to saw and seal the overlay at the deck joints in order to provide for a clean, controlled crack at each joint.

Conclusions

Thorma Joints are in good condition after 2 to 3 years and could be recommended for use on other projects. However, cost of $110.00 per L.F. (on Route 3 project) is expensive.

Consider: Typical 3-span bridge, 3 lanes each way, 12' outside shoulder, 5' inside shoulder, 4 expansion joints.

Total length of T-Joint required = [8(12) + 2 (5)] 4 = 424 L.F.

Total Cost = 424 ($110.00) = $46,640

Thorma Joint
Linear Dynamics Co.
Prismo Safety Corporation
Pennsdale, PA
717-546-6041 (Main Office)

Contact: Harry Hawkins
Linear Dynamics
400 Lanidex Plaza
Parsippany, NJ 07054
201-884-0300 (New Jersey Office)

The Thorma Joint system has been installed on the following projects within the last four years.

1. New Jersey Turnpike, Exit 6, Delaare River Bridge
2. Garden State Parkway, MP 148-160, Elmwood Park
3. Garden State Parkway, MP 112-125, Shrewsbury-South Amboy
4. Garden State Parkway, MP 60-84, Manahakin-Toms River

Gerald Kauffman (VEn)
Jerry Kauffman

Figure A. Typical Condition of 2-3 Year old Thorma-Joint on The Garden State Parkway.

Figure B. Typical Condition of 2-3 Year Old Thorma-Joint on the Garden State Parkway