HIGH MOLECULAR WEIGHT METHACRYLATE SEALING OF A BRIDGE DECK

Construction Report for
Iowa DOT Project HR-2031
FHWA Project DTFH71-86-948-IA-25

For presentation at the
67th Annual Meeting of the
Transportation Research Board
Washington, D.C.
January 1988

Highway Division
Iowa Department of Transportation

Marks, V. J.

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May 1987

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ABSTRACT

The Iowa Department of Transportation used a high molecular weight methacrylate (HMWM) resin to seal a 3,340 ft. x 64 ft. bridge deck in October 1986. The sealing was necessary to prevent deicing salt brine from entering a substantial number of transverse cracks that coincided with the epoxy coated top steel and unprotected bottom steel.

HMWM resin is a three component product composed of a monomer, a cumene hydroperoxide initiator and a cobalt naphthenate promoter. The HMWM was applied with a dual spray bar system and flat-fan nozzles. Initiated monomer delivered through one spray bar was mixed in the air with promoted monomer from the other spray bar. The application rate averaged 0.956 gallons per 100 square feet for the tined textured driving lanes. Dry sand was broadcast on the surface at an average coverage of 0.58 lbs. per square yard to maintain friction.

Coring showed that the HMWM resin penetrated the cracks more than two inches deep. Testing of the treated deck yielded Friction Numbers averaging 33 with a treaded tire compared to 36 prior to treatment. An inspection soon after treatment found five leaky cracks in one of the 15 spans. One inspection during a steady rain showed no leakage, but leakage from numerous cracks occurred during a subsequent rain. A second HMWM application was made on two spans to determine if a double application would prevent leakage. This evaluation has not been completed.

Marks, V. J.

High Molecular Weight Methacrylate Sealing of an Iowa Bridge Deck

PART I - INITIAL APPLICATION

INTRODUCTION

The US 136 bridge over the Mississippi River at Keokuk, Iowa, is a 15 span 3,340 ft. x 64 ft. continuous welded plate girder bridge. It was designed by Howard, Needles, Tammen and Bergendoff of Kansas City, Missouri, and constructed by Shappert Engineering Company of Belvidere, Illinois, in 1984 and 1985. Inspection of the construction was by Howard, Needles, Tammen and Bergendoff. The bridge was opened to traffic November 23, 1985.

The bridge deck placement began November 6, 1984, and was completed August 15, 1985. The deck was placed in 16 sections beginning on the Iowa side of the river. The concrete was placed east to west in each section using a telescoping belt conveyor and a full width finishing machine. The completed portion of the deck was used as the work area for unloading concrete trucks when placing the next section and for storage of equipment.

Very fine, tight transverse cracks in the deck were observed before deck placement had been completed. Further observation revealed that the cracks were full depth of the deck and during periods of rain, water was observed dripping from the

cracks. The combined effects of stresses from drying shrinkage and changes in moment from concrete placement are the apparent cause of the cracking. As the moisture dripped and evaporated from the bottom of the deck, an efflorescent deposit was left on the concrete. It was determined that at least 215 cracks allowed water to pass through the bridge deck.

It was also determined that the cracks coincided with the location of the transverse reinforcing steel. This would allow corrosive deicing salts to reach the uncoated bottom layer of transverse reinforcing steel which is directly below the epoxy coated top layer. The deicing salts could also contaminate the supporting girders causing them to corrode.

In an attempt to determine a method for preventing the intrusion of water into the cracks, three conventional sealants were applied on small areas of the bridge deck. Two of the sealants were very fluid and could be applied by spraying or brooming while the other one was quite viscous and was applied to each crack with a squeeze bottle. This was impractical as the cracks were very difficult to follow due to the deep transverse tined texture of the deck. Although all three sealants penetrated into the cracks, none prevented the passage of water through the cracks.

In February 1986 it was decided to investigate the use of HMWM resin as a deck sealant (1). The California Department of Transportation had made successful experimental applications of HMWM resin (2) and had developed specifications.

HMWM resin was obtained from two suppliers for experimental purposes. The resins were mixed and applied by hand to three 50 ft. long sections in the inside lane of the eastbound roadway. Sand was sprinkled on the treated sections to maintain friction quality.

A steady rain occurred early the morning after application of the HMWM and observation from a catwalk beneath the bridge revealed water along the cracks in the treated areas as well as the untreated area. The question then became did the treated cracks leak or did the water come through untreated cracks and move laterally along the bottom of the treated crack? A ponding test was conducted and the treated sections did leak, although not as quickly as the untreated section. The ponding test also showed that leakage would occur on both treated and untreated areas in the morning and the leakage would cease in the afternoon. One explanation of this unexpected development, is a more rapid temperature rise (and corresponding expansion) of the concrete deck than of the steel girders.

Two HMWM formulations were then applied as a single application and a double application. These applications were com-

pleted by 7:00 a.m. before the deck temperature had risen. All HMWM treated areas were sprinkled with sand to maintain friction. Ponding tests early the next morning revealed slight leakage through the single application areas and no leakage through the double application areas of HMWM.

Friction of treated areas was tested with an ASTM E-274 friction test trailer and was deemed satisfactory.

With the information obtained from the field trials on the bridge deck and experiences of other Departments of Transportation, it was decided that a single application of HMWM resin applied when the deck temperature was relatively cool would be sufficient to prevent deicing salts from reaching the uncoated bottom layer of reinforcing steel.

The bridge contract with Shappert Engineering Company had not been closed, so it was decided to apply the HMWM resin by extra work order to the existing contract.

The California DOT specification for "High Molecular Weight Methacrylate Bridge Deck Treatment" was obtained and Iowa DOT Special Provision 668, "Special Provision for High Molecular Weight Methacrylate" was developed.

SPECIFICATIONS

The special provision used for this project was:

Special Provision 668 - Special Provision for High Molecular Weight Methacrylate Bridge Deck Treatment, August 5, 1986.

The standard specifications, series of 1984, are amended by the following additions. These are special provisions, and they shall prevail over those published in the Standard Specifications.

668.01 **DESCRIPTION.** This work shall consist of preparing the portland cement concrete surface and furnishing and applying High Molecular Weight Methacrylate (HMWM) treatment materials.

668.02 **MATERIALS.** The material used for treating the concrete shall be a low viscosity, non-fuming, HMWM resin conforming to the following:

HIGH MOLECULAR WEIGHT METHACRYLATE RESIN

Viscosity:	Less than 25 cps (Brookfield RVT w/UL adaptor 50 RPM @ 77°F) Calif. Test 434
Specific Gravity:	1.02 to 1.08 @ 77°F - - ASTM D 2849.
Flash Point:	Greater than 200°F (Pinsky-Martens CC)

Vapor Pressure: Less than 1.0 mm Hg @ 77°F - - ASTM D 323

Transition Temperature: Higher than 58°C - - ASTM D 3418 Tg (DSC)

A compatible promoter/initiator system shall be capable of providing a resin gel time of not less than 40 minutes nor more than 1 1/2 hours at the temperature of application. Gel time shall be adjusted to compensate for the change in temperature throughout treatment application.

The Contractor shall arrange to have a technical representative on-site to provide mixing proportions, equipment suitability, and safety advice to the Contractor and Engineer.

The promoter and the initiator, if supplied separate from the resin, shall not contact each other directly. Containers of promoters and initiators shall not be stored together in a manner that will allow leakage or spillage from one to contact the containers or material of the other.

A Material Safety Data Sheet (MSDS) shall be furnished for the HMWM resin to be used on this project. A certification showing conformance to these specifications shall be provided with each batch of resin. The following materials are approved as HMWM treatment material.

Company	Address	Brand
Rohm and Haas Company	727 Norristown Road Spring House, PA 19477	PCM-1100
Rohm and Haas Company	727 Norristown Road Spring House, PA 19477	PCM-1500
Revolan	P.O. Box 18922 San Jose, CA 95158	RS-200W
Adhesive Engineering Co.	1411 Industrial Road San Carlos, CA 94070	Concresive AEX 2075

The sand shall be an aggregate conforming to the quality requirements of Section 4110, "Fine Aggregate for Concrete", of the Standard Specifications and shall conform to the following limits for grading:

Sieve Size	% Passing Max.
No. 4	100
No. 8	90-100
No. 16	0-15
No. 50	0-5

It is the intention of this specification to allow the use of commercially available blast sands of No. #8/20.

668.03 SURFACE PREPARATION. Concrete surfaces shall be prepared by air cleaning the entire deck surface to be treated and blowing all loose material from visible cracks using high-pressure air. All accumulations of dirt and debris shall be removed from the surface. The surface to be treated shall be dry (visual inspection) and above 40°F prior to resin application.

668.04 APPLICATION OF HMWM. The rate of application of promoted/initiated resin shall be approximately 100 square feet per gallon in a single application; the exact rate shall be determined by the Engineer.

The application may be made by machine, using a two-part resin system utilizing a promoted resin for one-part and an initiated resin for the other part. The pressure at the spray nozzle shall not be great enough to cause appreciable atomization of the resin. Compressed air shall not be used to produce the spray.

The quantity of initiated, promoted resin shall be limited to 5 gallons of mixed resin at a time for manual application. A significant increase in viscosity prior to proper penetration shall be cause for rejection. The treatment shall be applied within 5 minutes after complete mixing.

The deck and sidewalk are to receive the HMWM resin treatment. The surfaces shall be flooded with resin, allowing penetration into the concrete and filling of all cracks. Excess material shall be redistributed by brooms within 5 minutes after application. Curbs and rails are not to receive this treatment; reasonable care shall be taken to keep these surfaces free from resin.

668.05 APPLICATION OF SAND. The entire treated area of the bridge deck shall have sand broadcast by mechanical means to effect a visually uniform coverage of 0.40 to 0.60 pound per square yard. The sand shall be applied by a common lawn broadcast-type seeder/spreader. If cure time allows, sand shall be placed 25 to 35 minutes after the resin has been applied and before any gelling of the resin occurs. The sand shall be dried and shall have a maximum total moisture content of less than 0.5 of the aggregate absorption determined in accordance with Iowa Laboratory Test Method 202.

668.06 LIMITATIONS. The Contractor shall use every reasonable means to protect persons and vehicles from injury or damage that might occur because of his operations. During the construction, the Contractor shall provide such traffic control as required by the contract documents. Iowa DOT Standard Specifications, Articles 1107.08 and 1107.09, shall also apply.

The road shall be kept open to traffic unless otherwise directed by the Engineer. Except when an accelerated work schedule is required, no work will be permitted on Sundays and holidays. The Contractor may restrict traffic but shall permit traffic to pass safely at all times, except for occasional, unavoidable interruptions.

Application of HMWM materials shall be made between the hours of 11:00 p.m. and 7:00 a.m. HMWM Treatment of the entire bridge deck shall be completed between April 1 and October 31. The temperature of the surfaces to be treated shall range from 40°F to 100°F. Care shall be exercised to prevent spillage of HMWM material or solvents into waterways.

Solvent for cleaning and flushing of equipment, tools, etc., shall be used in such a manner to minimize personal and environmental hazards, as approved by the Engineer. A soap and water wash station shall be provided for the workers at the job site.

Traffic shall be permitted on the treated surface when the sand cover adheres sufficiently and there is no tracking of HMWM material. Particular care shall be exercised when there is a possibility of tracking material on asphaltic concrete at the end of the bridge.

668.07 **METHOD OF MEASUREMENT.** The area treated will be calculated by the Engineer, based on plan dimensions, and will be paid for as HMWM Bridge Deck Treatment.

Furnishing the high molecular weight methacrylate resin will be measured by the gallon of mixed material actually placed, by count. No payment will be made for material wasted or not used in the work.

668.08 **BASIS of PAYMENT.** The contract price paid per square foot for HMWM Bridge Deck Treatment shall include full compensation for furnishing all labor, materials (except treatment resin) tools, equipment and incidentals, and for doing all the work involved in preparing concrete surfaces, applying treatment material and sand, providing a technical representative, and clean up, as specified herein and as directed by the Engineer.

The contract price paid per gallon for Furnish HMWM Bridge Deck Treatment Material shall include full compensation for furnishing all resin treatment materials to the site of the work, ready for application, as specified herein and as directed by the Engineer.

Two changes to Special Provision 668 are proposed for future HMWM treatment projects. In section 668.03, the modification would read "The surface to be treated shall remain dry for 24

hours and above 40°F prior to resin application". The period when the treatment would be allowed in Section 668.06 would change to "between April 1 and September 30".

MATERIALS

The contractor opted to use RPM-2000W produced by Revolan Systems, an approved equal to one of four HMWM resins from three suppliers allowed by Special Provision 668. It is a three component system composed of a monomer, a cumene hydroperoxide initiator, and a cobalt naphthenate promoter. Two ounces of promoter and two ounces of initiator were added to one gallon of monomer as recommended by the producer.

The dried sand required for maintenance of friction was a natural sand from Northern Gravel at Muscatine, Iowa. The gradation is in Table I.

EQUIPMENT

The system used for the application of the HMWM was developed originally by Leo Ferroni, formerly with the California DOT, now a Technical Consultant.

The system was transported on a four-wheeled flatbed trailer pulled by a small farm tractor. Barrels of resin and two positive displacement pumps were placed on the bed of the trailer and two spray bars were mounted horizontally parallel to each other across the rear of the trailer (Figure 1). Each bar had

12 nondrip, flat-fan nozzles spaced 12 inches apart. The nozzles of each bar were connected in series with flexible tubing and then connected to a pump. The positive displacement feature of the pumps was negated by a pressure regulated recirculation system.

The parallel spray bar mixed the HMWM in the air by having the nozzles tilted so that the fan shape of the front and rear opposing nozzles intersected about three inches above the deck surface. One bar sprayed from a barrel that had monomer mixed with the initiator required for two barrels and the other bar sprayed from a barrel of monomer mixed with the promoter required for two barrels.

Also mounted on the trailer were floodlights for nighttime operation

A rotary power broom, hand brooms, and shovels were used to clean the deck. An air compressor furnished air for final cleaning.

Two lawn-type broadcast fertilizer spreaders were used to spread the dry sand.

DECK PREPARATION

A rotary power broom was used initially to remove sand and to loosen dirt from the bridge deck. Stiff bristle hand brooms

were used to loosen the dirt in the transverse grooves. After brooming, the deck was blown clean with compressed air. The deck was usually cleaned in the morning and sealed that night. When the sealing was more than 24 hours after cleaning, re-cleaning with hand brooms and compressed air was required.

Styrofoam was cut to fit the drains and sealed with caulking compound to prevent the HMWM resin leaking into the river.

HMWM RESIN APPLICATION

Special Provision 668 limits application to the hours between 11:00 p.m. and 7:00 a.m. It was decided to allow application until 8:00 a.m. and also agreed that the bridge deck surface would be dry for 24 hours prior to sealing.

In preparation for a September 17 application, the system was calibrated using water instead of HMWM resin for a fan width of 12 inches from each nozzle. Nozzle delivery tables showed this to require about 20 psi pressure with the resin at about 65°F. Two barrels of monomer were prepared for application but the planned September 17 application was cancelled because of rain and there continued to be rains throughout September and into October.

The first application of HMWM was on October 7, 1986. The operation began by 4:00 a.m. with a calibration check in the contractor's staging area. It was observed that the system

would not produce the required 12 inch fan pattern. This was attributed to the material being more viscous at the current temperature of 45°F than the 65°F temperature at the time of the original calibration. The pressure was increased to 35 psi to obtain the 12 inch fan pattern and application began on the outside westbound lane.

The HMWM was sprayed 11 feet wide and was broomed to make an application width of 17 feet (Figure 2). The intended application rate was one gallon of HMWM per 100 square feet. With constant pressure, the application rate was regulated by the forward speed of the tractor. The amount of HMWM resin in the 55 gallon drums prior to and after treatment of a section was estimated after determining the depth remaining with a rod. Travel was intended to be 60 feet per minute. This resulted in an application rate of 1.304 gallons per 100 square feet.

The speed of the farm tractor was increased for the application of the second 100 gallons of HMWM resin to reduce the rate of application. The travel speed was too fast resulting in areas with insufficient resin and the equipment was moved back to touch up those places. For subsequent applications, the travel speed was adjusted to give sufficient resin as determined by observation.

Sand was applied about 90 minutes after resin application due to the very cool temperature delaying the gel time. The air

and deck temperature during the application ranged between 48°F and 55°F. Higher temperatures would have reduced the gel time of the resin allowing sand to be spread sooner after application.

The sand was spread with two broadcast type lawn fertilizer spreaders. Various speeds and transverse spreader locations were tried until the desired coverage was obtained. Sand coverage varied between 0.51 lbs. and 0.61 lbs. per square yard with the average being 0.58 lbs. per square yard on the deck and 0.52 lbs. per square yard on the sidewalk. This sand was intended to provide temporary friction properties until the HMWM coating was worn away.

The eastbound inside lane was sealed on October 8, 1986. The areas that had been previously treated for ponding tests were not retreated. The outside eastbound and the inside westbound lanes were treated October 10, 1986.

The sidewalk was treated by applying the resin with garden sprinkler cans and spreading with squeegees and brooms. The application rate averaged 0.896 gallon per 100 square feet which was slightly less than the 0.956 gallon per 100 square feet on the driving portion of the deck which has a tined texture.

It was at least 24 hours after treatment before vehicle traffic was allowed on the bridge. There was minor tracking, but no adverse effects were observed because of tracking.

COST

The cost of sealing the bridge is broken down as follows:

1.	236,050 sq. ft. of treatment @ 0.35	$82,617.50
2.	2,256 gal. HMWM @ 35.45	79,975.20
3.	Traffic control - lump sum	12,500.00
	Total	$175,092.70

EVALUATION

A total of six, two-inch diameter cores were drilled from both inside lanes October 14, 1986. They were drilled, on a crack, two inches deep to avoid damaging the epoxy coating of the top reinforcing steel which has only two inches of cover. The core holes were filled with portland cement concrete and were treated with HMWM resin the following day.

When the cores were split to determine penetration, the split did not always follow the crack. There were some instances where the concrete fractured instead of the crack which is indicative of the bonding capabilities of the HMWM resin.

The bottom edges of the cores were treated with a 50% concentrated sulfuric acid/50% water solution. Heating to 140°F in

an oven for two hours caused the organic resin to turn black. The test indicated that the HMWM had penetrated at least two inches deep at all core locations.

Friction of the treated deck was tested with an ASTM E-274 trailer November 3, 1986, in all lanes. The friction numbers ranged from 27 to 39 averaging 33 with the treaded test tire and ranged from 20 to 33 with an average of 24 with the smooth tire.

The underside of the bridge was inspected October 25, 1986, during a 0.25 inch rain. There was leakage observed from five cracks between piers seven and eight. Another inspection was made during light rains March 18 and March 25, 1987, and no leakage was observed. Two inspections were made April 13 and 14, 1987, from all catwalks during steady rains and no leaking cracks were found.

Another inspection to check for leakage was made on August 25, 1987 during a steady rain very much like that of April 13 and 14. There had been a substantial period with free water standing on the surface. Leakage was identified in all spans of the bridge deck. There were over 300 cracks under the eastbound lanes and over 400 cracks under the westbound lane showing some leakage. Water was not dripping from any cracks. It would appear from visual observation that the leakage was at a reduced rate compared to leakage prior to the treatment.

Some leakage was noted from cracks that had no efflorescent deposit. There is a possibility that some new cracks have developed.

PART II - SECOND APPLICATION

CONSIDERATION OF SECOND APPLICATION

With evidence that one application of HMWM had failed to prevent leakage, it was necessary to consider additional protective measures. A second application of HMWM or an Iowa method dense concrete overlay were the only further protection given serious consideration. The Iowa method overlay has been very successful on another long bridge that developed substantial transverse cracking immediately following construction.

The HMWM system had not been fully evaluated. In the laboratory, a double application of HMWM had been successful in preventing leakage through cracks believed to be wider than those in the bridge deck. One potential problem was that the first HMWM application had filled 2/3 of the depth of the transverse grooved texturing. The second application of HMWM would certainly fill the balance of the transverse groove texture. A small trial on the Keokuk bridge showed that the HMWM material was removed very quickly and effectively by sandblasting.

MATERIALS

The HMWM material used for the second application was the same RPM-2000W used for the initial application.

In an effort to obtain better frictional properties, a manufactured crushed quartzite sand was obtained from Del Rapids, South Dakota. The gradation of the dried sand is given in Table 2.

WEATHER CONDITIONS

The decision to use the second application of HMWM was made soon after the observation of leakage on August 25. Delivery of the HMWM material required almost four weeks. The manufacturer strongly recommended that the HMWM not be applied at temperatures below 50°F. Most of October was quite cold and it appeared that application would be delayed until warm weather in 1988. Fortunately in early November the low temperatures for three nights were 58° to 60°F.

DECK PREPARATION

The City of Keokuk used their street sweeper to remove essentially all of the dirt and debris. The drains were again plugged with Styrofoam sheeting and caulked to prevent HMWM from running into the river. Compressed air was used to blow the deck clean immediately ahead of the HMWM application.

HMWM RESIN APPLICATION

The second application of HMWM was placed full width of the deck on 421 feet from an expansion assembly 15 feet east of pier 6 to pier 8. Traffic was restricted to one lane each direction with the other two lanes closed for treatment. The second treatment was applied manually by Iowa DOT personnel. The Iowa DOT maintenance personnel had set up traffic control and blown the westbound inside lane clean on November 3, 1987, a comfortable 60°F night. The HMWM was hand mixed in five gallon buckets and poured onto the deck. Beginning at 5:15 a.m. soft, nylon bristled push brooms were used to spread the HMWM 15' wide for an average coverage of 0.82 gallons per 100 sq. feet. Two push brooms were used behind the application to move the excess material ahead. HMWM application on the westbound lane was completed at 6:00. The crushed quartzite sand was applied. Sand application should have begun earlier, as the first portion of HMWM had begun to gel. The sand coverage was 1.17 pounds per sq. yard.

Application of HMWM to the eastbound inside lane began at 7:00 a.m. and was completed at 7:40. The operation was the same as for the westbound lane except that sand spreading began at 7:25. Sand coverage for the westbound lane was 1.31 pounds per sq. yard. The temperature at 8:20 was 66°F with a daily high of 79°F. Traffic was allowed on both the eastbound and westbound applications at about 3:00 p.m.

The Iowa DOT maintenance personnel had blown the outside westbound lane clean and were ready for application of HMWM at 5:00 a.m. on November 4 (night time low of 58°F). Application procedures remained unchanged and sand application began at about 5:15 a.m. HMWM application was finished at 5:40. Quartzite sand was used at 1.31 pounds per square yard.

The outside eastbound lane and sidewalk were treated from 6:30 to 7:10 a.m. The sand coverage on the outside eastbound lane was 1.46 pounds per sq. yard. No quartzite sand was used on the sidewalk. The temperature at 8:00 was 61°F.

EVALUATION

The depth of penetration of the second application can not be determined as there is no way to distinguish from the organic HMWM material of the initial application that penetrated the two inches to the top steel.

Friction testing has been conducted prior to treatment, twice after the initial application and once since the double application (Table 3). The Friction Numbers of the surface with a single application are similar to those prior to treatment. The crushed quartzite sand has given improved Friction Numbers after the second application. Continued testing will be necessary to determine the longevity of the improved Friction Numbers.

There have been no rains of sufficient duration and intensity to determine if a double application will prevent leakage.

PRELIMINARY CONCLUSIONS

The HMWM resin penetrated the fine cracks to a depth of at least two inches. A single application of HMWM reduced the leakage, but failed to prevent leakage. Further evaluation is necessary to determine if a double application will prevent leakage. There was an initial loss of frictional properties after HMWM treatment, but as traffic wore away the surface coating, the Friction Numbers returned to pretreatment levels. The crushed quartzite yielded improved Friction Numbers immediately following the second application of HMWM.

ACKNOWLEDGEMENTS

The HMWM treatments and evaluation were partially funded by the Federal Highway Administration. The excellent work of all those involved with the HMWM treatments allowed both initial and second applications of a material new to Iowa with very few problems. Excellent technical advice was provided by Al Klail and Ersell Ingram of the Revolan Systems and also by Leo Ferroni, a private consultant. Jeff Boldt and the other Shappert Engineering personnel and Iowa DOT personnel are to be commended on an outstanding job of applying the HMWM material. Ron Thompson and S. Thomas McKay of the Iowa DOT Mt. Pleasant Resident Construction Office provided excellent project inspection. Mr. Thompson compiled an excellent doc-

umentation of the coverage of both the resin and the sand and also the air and surface temperature during the initial application of the resin. The cooperation of the Illinois DOT personnel was appreciated.

REFERENCES

1. A Study of the Transverse Cracks in the Keokuk Bridge Deck, Iowa Department of Transportation, July 1986

2. Krauss, P., New Materials and Techniques for the Rehabilitation of Portland Cement Concrete, Report FHWA/CA/TL-85/16 California DOT 1985

TABLE TITLES

1. Muscatine Sand Gradation
2. Del Rapids Sand Gradation
3. Friction Testing

TABLE 1

Muscatine Sand Gradation

Sieve No.	% Passing
8	100
16	7.9
30	0.6
200	0.4

TABLE 2

Del Rapids Sand Gradation

Sieve No.	% Passing
4	100
8	85
16	13
30	1.2
50	0.4
100	0.2
200	0.1

TABLE 3

Friction Testing

ASTM E-274 at 40 MPH

	Friction Number	
	Treaded Tire	Smooth Tire
Prior to treatment	36	23
After Single Application		
6-15-87	33	20
10-12-87	40	21
After Double Application		
11-16-87 Driving Lane	50	34
Passing Lane	61	48

FIGURE CAPTIONS

1. Spray Bar Mounting on the Flatbed Trailer
2. Application of HMWM Resin

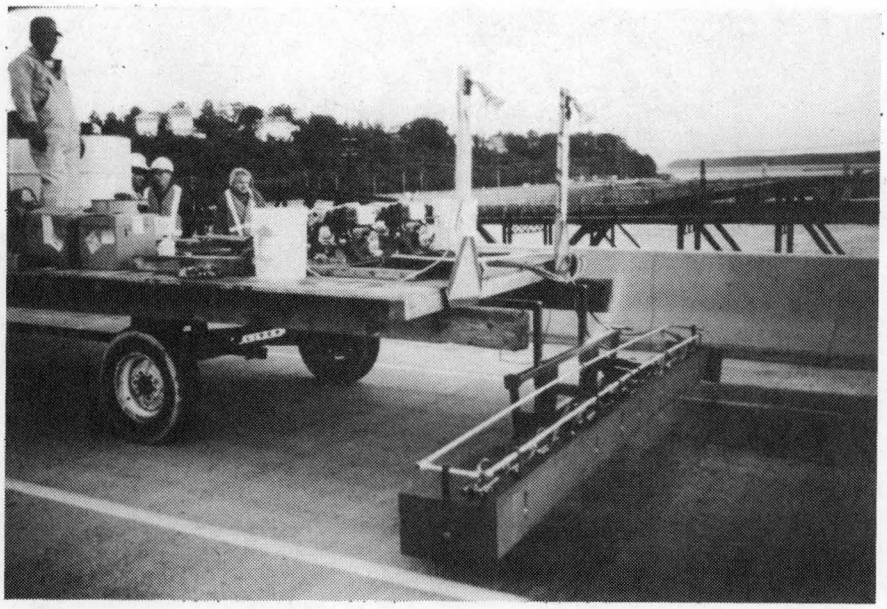

Figure 1

Spray Bar Mounting on the Flatbed Trailer

Figure 2

Application of HMWM Resin