THE PROTECTION EFFECTIVENESS OF WATERPROOF MEMBRANE SYSTEMS ON BRIDGE DECKS IN LOUISIANA

Final Report

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Research Report No. FHWA-LA-78-121

Research Project No. 75-2C

Conducted By
LOUISIANA DEPARTMENT OF TRANSPORTATION
AND DEVELOPMENT, OFFICE OF HIGHWAYS
Research and Development Section
In Cooperation with
U. S. Department of Transportation
FEDERAL HIGHWAY ADMINISTRATION

DECEMBER 1978

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ABSTRACT

The effects of de-icing salts on concrete and reinforcing steel is well documented, and efficient methods of protection from the penetrating chloride ions have long been sought. Concrete bridge decks need the protection, and waterproofing the concrete appeared to be a possible answer to this problem. With the development of waterproof membrane systems, it was felt that an efficient means of protection was obtainable.

The aim of this research study was to evaluate the effectiveness of certain concrete bridge deck waterproofing membranes under conditions that prevail in Louisiana. This research study included research evaluation of experimental installations on an exit ramp and a bridge on the interstate highway in North Louisiana, in addition to laboratory evaluations of the membrane systems.

Laboratory evaluations included various tests (tension tests, bend tests, heat-aged tests and electrical resistance tests) which subjected these waterproofing membrane systems to varying conditions to check their acceptability. Field evaluations included visual observations and electrical resistivity tests. Installation procedures were monitored closely and a diary was kept on all activity.

The primary conclusion reached herein was that, using the electrical resistivity as the chief test for waterproofing ability, all membrane systems evaluated in the field failed to achieve total impermeability of the concrete deck. The primary recommendation of the research report is that the State of Louisiana not accept the concrete bridge deck membrane systems for use as waterproofing materials.

IMPLEMENTATION STATEMENT

A recommendation has been made that the State of Louisiana not accept the concrete bridge deck waterproofing membrane systems evaluated in this research study for use as 100% impermeable waterproofing materials on concrete bridge decks. As a result, no membrane systems have been used on any further construction projects in Louisiana.

Certain of these or other concrete membrane systems might be considered for use at particular locations where other than 100% impermeability need be obtained or required. The particular type of use would be the controlling factor for consideration, along with the economic considerations.

INTRODUCTION

The effects of de-icing salts on concrete and reinforcing steel is well documented, and efficient methods of protection from the penetrating chloride ions have long been sought. Concrete bridge decks need the protection, and waterproofing the concrete appeared to be a possible answer to this problem. With the development of waterproof membrane systems, it was felt that an efficient means of protection was obtainable.

Various waterproof membrane systems had been developed and looked promising, so several of these systems were selected to be evaluated for their effectiveness in waterproofing concrete bridge decks from the chloride ions. It was felt the selected concrete bridge decks in North Louisiana would provide a fair test for these membrane systems.

PURPOSE

The aim of this research study was to evaluate and ascertain the effectiveness of concrete bridge deck waterproofing membranes under conditions that prevail in Louisiana. This research study was to evaluate experimental field installations which were accomplished by Department maintenance forces, and included also laboratory evaluations by research personnel. The acceptability of the waterproofing membrane systems was to be determined, with any unusual conditions noted.

SCOPE

Field experimental installations by Department maintenance forces included six types of waterproofing membrane systems on the Bayou Lafourche Bridge and two types of waterproofing membrane systems on an exit ramp off the Ouachita River Bridge (both facilities on Route I-20). Behavior of the membrane-asphaltic concrete overlay system, when subjected to the heat of the summer months and any freeze cycles of northern Louisiana's winter months, was of primary concern to the researchers. Electrical resistivity measurements were taken and evaluated by research personnel.

Laboratory evaluations included various tests which subjected these waterproofing membrane systems to varying conditions to check their acceptability. Tests included the tension test (a version of the California Minicracker), electrical resistance test (in conjunction with the tension test), the bend test and the heat-aged bend test.

METHODOLOGY

This research study involved both a field installation and evaluation phase, and a laboratory evaluation phase. The seven waterproof membrane systems that were tested and evaluated were Hydro-Ban, RVN-30, Hydro-Ban, RVN-45, Heavy Duty Bituthene, Protecto Wrap, Royston and high and low heat Superseal 4000. High-heat and low-heat Superseal 4000 were tested in the laboratory, with only low-heat Superseal 4000 installed in the field.

A. The Laboratory Evaluation Phase

This phase attempted to define the limits that the waterproof membrane systems should have been able to be subjected to and withstand, according to the prevailing conditions. Temperature ranges and cycling conditions differed from those of other states. The laboratory testing program included the following:

1. Electrical Resistance Test - This test was performed in conjunction with the tension test. After the membrane was applied to the block, a silicone dam was formed on top of the membrane to approximately four by six inches. The block was then placed in a metal pan of water 1/2 inch deep. The dam was also filled with water. With this arrangement, one lead from an ohm meter was attached to the metal pan containing the water and partially submerged test specimen, and the other lead was placed in the water contained by the dam. The resistivity of the membrane was recorded as a function of time. The initial resistivity of the membrane was determined at room temperature ($72^{o}F \pm 3^{o}$) prior to the specimen being placed in the freezer for 24 hours. The final resistivity was determined at the appropriate temperature (-5^{o}, 0^{o} and 10^{o} F)

after the tension test was performed.

2. Tension Test - This test utilized a version of the "California Minicracker" whereby a membrane was applied on a 2-by 6-by 12-inch concrete block. The block was attached to a device which elongated, causing the block to crack in tension through the cross-sectional mid-point. The cracked area was allowed to open 1/10 inch. Tests were performed at -5^{o}, 0^{o}, $+5^{o}$, and $+10^{o}$F.
3. Bend Test - This test involved the bending of a 1-by 8-inch strip of the membrane material around a 1 inch diameter mandrel at the temperatures mentioned in the previous testing program.
4. Heat-Aged Bend Test - This test was similar to that of the regular bend test with the exception that the membrane specimen was placed in an oven for 28 days at 140^{o}F prior to being placed in the freezer chamber and subjected to the bend test.

Figures 19 through 30 in the Appendix show the laboratory conditions, application and/or results pictorially. The laboratory evaluation phase took place after the installation of materials in the field and during the time of the field evaluations.

B. The Field Evaluation Phase

This phase attempted to evaluate the effectiveness and field performance of the waterproof membrane systems as installed on the following two projects:

a) Bayou Lafourche Bridge, Route I-20, State Project Number 451-07-19, F.A.P. I-20 3(55) 127.
b) Ouachita River Bridge (exit ramp), Route I-20, State Project Number 451-06-16, F. A. P. I-20 3 (54) 116.

The field evaluation program included the following:

1. Upon completion of the waterproof membrane systems application, but prior to the asphaltic concrete overlay, the electrical resistance of the membrane was determined by means of a half-cell corrosion detecting device.

2. After completion of the asphaltic concrete overlay, electrical resistance was again obtained to determine if any damage to the membrane had occurred during construction of the overlay.

3. Electrical resistance measurements were taken at intervals of time after the original installation when manpower, weather and time conditions were favorable to obtain these measurements.

Following is the geographical location of these state projects as shown in Figure 1.

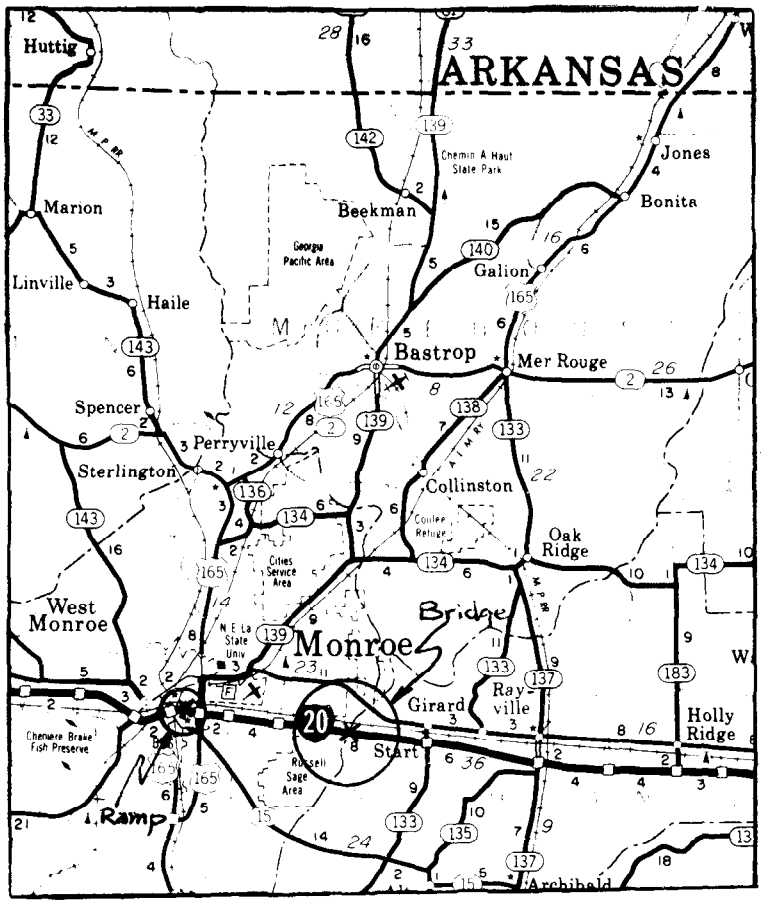

Figure 1
Geographical Location of
Field Installations

Project specifications for state projects 451-06-46 and 451-07-19 are included in the Appendix, with information on the materials used on the projects included in the specifications.

INSTALLATION

A. GENERAL

A meeting was held June 3, 1975 to verify quantities of materials received, and another was held June 9, for pre-construction planning, discussions and coordination finalizing.

Table 1 gives the span locations of the various waterproof membrane systems on the exit ramp off I-20 eastbound in Monroe and the bridges over Bayou Lafourche on I-20 for these experimental installations. Span and reading locations for these bridges are shown in Figure 2.

Table 1

SPAN LOCATIONS OF WATERPROOF MEMBRANE SYSTEMS ON BRIDGES

Exit Ramp off I-20 in Monroe

System No.	Membrane	Location Spans	Remarks
1	Superseal 4000 Low Heat	10	Eastbound exit ramp, Monroe
5	Hydro-Ban RVN-45	11	Eastbound exit ramp, Monroe

Bayou Lafourche Bridge

System No.	Membrane	Location Spans	Remarks
1	Superseal 4000 Low Heat	1 & 2	Both lanes, left bridge (WB)
2	Hydro-Ban RVN-30	3	Both lanes, left bridge (WB)
3	Protecto Wrap M-400	5 & 6	Both lanes, left bridge (WB)
4	Heavy Duty Bituthene	7 & 8	Both lanes, left bridge (WB)
5	Hydro-Ban RVN-45	4	Both lanes, left bridge (WB)
6	Royston No. 10	9	Both lanes, left bridge (WB)
	Reference	4	Both lanes, left bridge (WB)

Bayou Lafourche I-20

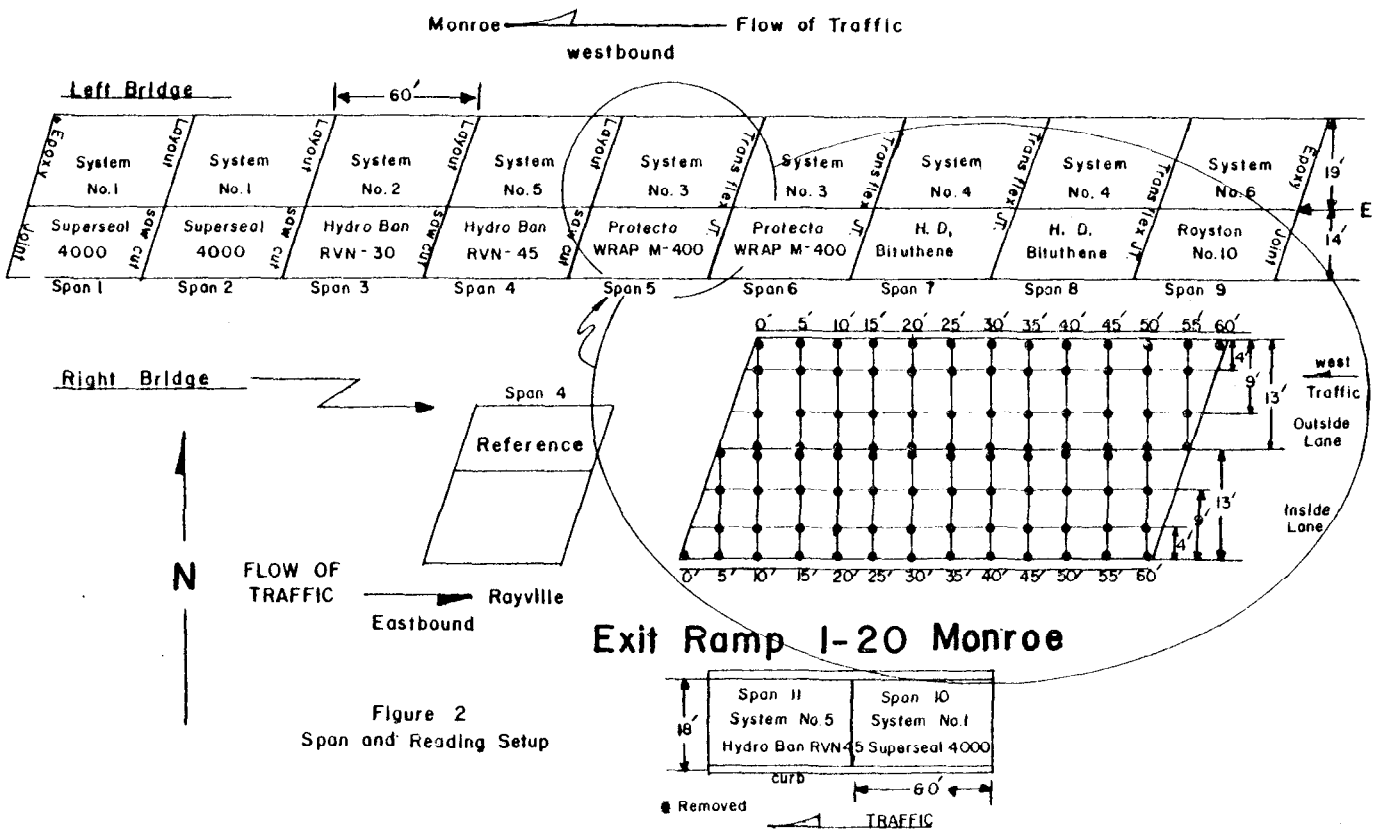

Figure 2
Span and Reading Setup

B. MATERIALS

System No. 1 (Superseal 4000) - This is a high or low heat, hot poured material from a double boiler, single component hot applied elastomeric PVC polymer membrane used with 65 lb. roll roofing paper (ASTM 224) as a part of the system.

System No. 2 (Hydro-Ban RVN-30) - This is a reinforced vinyl-neoprene or vinyl-butyl elastomeric waterproof membrane used with an adhesive/primer, a spray topping and tape weld as a part of the system.

System No. 3 (Protecto Wrap) - This system includes a cold applied primer, membrane, mastic and protection sheet for use on bridge decks as a positive barrier against the penetration of water, salt solutions and other contaminants.

The membrane is provided in rolls interwound with a release film to prevent self-adhesion of the material. The membrane is a laminate of premium grade aromatic tars modified with synthetic resins and reinforced with a synthetic non-woven fabric.

System No. 4 (Heavy Duty Bituthene) - This membrane is a high-strength, heat-resistant mesh embedded between a self-adhesive rubberized asphalt and non-tacky bituminous compound. It is supplied in rolls interwound with a special release paper. A primer and a mastic are part of the system.

System No. 5 (Hydro-Ban RVN-45) - This is a reinforced vinyl-neoprene or vinyl-butyl elastomeric waterproof membrane used with an adhesive/primer, a spray topping and tape weld as a part of the system.

System No. 6 (Royston) - This is a prefabricated laminate consisting of an impregnated fiberglass mesh sandwiched between layers of a bituminous mastic with a top surface of polyester film used with a primer as a part of the system.

C. INSTALLATION PROCEDURES AND FIELD PROBLEMS

1. General

Installation procedures began June 16, 1975 on the exit ramp of I-20 at Monroe (State Project Number 451-06-46). The ramp was closed to traffic and maintenance forces installed three (3) expansion joints, one Transflex and two epoxy joints. The Transflex joint was installed connecting Span 10 and Span 11, while an epoxy joint was installed at the beginning of Span 10 and another at the end of Span 11. The two spans were sandblasted and small holes or spalls in the deck on the bottom edge of the curbs were filled with a grout of sand and epoxy. Weather conditions were humid with an air temperature of 92°F.

The concrete research unit installed permanent ground points in the top mat steel on each span, for the purpose of half-cell corrosion detection readings and future resistivity readings on each waterproof membrane that was to be installed. The ground points were installed in the steel in the concrete hand rail post. Half-cell readings were taken on each span prior to the installation of each of the waterproof membrane systems.

2. I-20 EXIT RAMP,*MONROE

a. System 1 (Superseal 4000 Low Heat)-During the installation of Superseal 4000 June 17 on Span 10, the material had to be melted for about one hour into a liquid at a temperature of 300°F. The material was poured from 5-gallon pails onto the bridge deck and a rubber squeegy was used to spread the material along the length of the span at least 3 ft. wide, the width of the 65-lb. super smooth roofing paper, which was in 36-ft. lengths.

*NOTE: The report format for the Installation Procedures and Field problems is in the form of a listing by systems and a discussion of each system installation. The installation procedures are not necessarily in order by date or sequence. Some procedure reporting may be repeated for various systems.

The roofing paper was placed immediately without being overlapped, while the material was hot. The paper adjoined at the edges and butted together. Once the paper was placed, a light roller was used to press the paper to the membrane, which was very elastic. There was no paper on the curb, so the sides of the curb were coated with Superseal 4000 alone.

On June 19 installation operations consisted of overlay work on the exit ramp of I-20 in Monroe. The overlay was to be $1\frac{1}{2}$ inches of hot mix, furnished by Bentz and Elmore Contractors of Monroe. Span 10, with the Superseal 4000 membrane, was in a fairly soft condition. The paper could be moved slightly with the feet and the exposed material was very tacky. Span 11, covered with the Hydro-Ban RVN-45, appeared in good condition.

A tack coat was applied to the west end of the Superseal 4000 membrane for 20 feet for a tapered overlay to Span 10. The tack coat covered approximately 50% of the total area.

The first hot mix overlay consisted of a 9 ft. wide strip on the inside lane of the spans and on the approach taper west of Span 10. The temperature of the hot mix when it left the plant was $325^{o}F$. The temperature of the overlay surface was $260^{o}F$ and the air temperature was $86^{o}F$. Trouble began when the tires of the loaded truck crossed the joint on Span 10 in a braking position on the downgrade. The felt paper on the Superseal 4000 membrane system began tearing and sliding forward for approximately 10 to 15 inches under both sets of wheels, as shown in Figure 3 on the following page.

Figure 3
Truck Slides and Rolls Felt Paper
from System 1 on Exit Ramp in Monroe

Even though the paper wasn't shoved, it was severely damaged.

Rolling of the hot mix overlay began on the first 9 ft. spread, moving back uphill on the Superseal 4000 system span. The hot mix began displacing after approximately 30 feet on the span, and the roller moved off the span for awhile. The second hot mix truck arrived to place the remaining 9 feet of overlay and paving started at 11:15. Again, the same type of action occurred on the Superseal 4000 felt paper as the hot mix truck fed the paver. The truck was stopped and the paver was loaded with just enough material to complete the paving of the Superseal 4000 system span. All torn paper was removed and the remainder of the spans were paved. Soft spots remained in some areas of the Superseal 4000 span.

b. System 5 (Hydro-Ban RVN-45)-On June 17, 1975 while work continued on the joints, the installation of Hydro-Ban RVN-45 waterproofing membrane (System No. 5) began on Span 11. At 8:45 with the temperature at 88°F, the adhesive epoxy Hydro-Ban 10 was applied. The company representative was present during the entire application of his product. The epoxy was poured, (after addition of a thinning solution to correct the consistency to the width of the membrane (48 in.) and the length of the span (60 ft.) The material was then left to cure approximately 20 minutes, until it would not stick to the finger upon touch. The membrane came in 100 ft. rolls 48 in. wide. The adhesive side of the membrane was covered with a thin protective sheet of plastic paper, which had to be removed as the membrane was unwound and placed on the deck. Care had to be taken not to trap air underneath while pressing the membrane to the concrete surface.

After one length of the deck was covered with the membrane, another section of concrete surface was prepared with an adhesive coating, and the membrane was placed next to the edge of the previous membrane. Note that the membrane was not overlapped during the covering of the entire span. After the span was covered, the exposed opening on joint between each strip of membrane had to be epoxied with a clear vinyl organic solution.

A 1 inch wide membrane tape was then placed to connect and waterproof this opening between the membrane strips. A squeeze-out of the epoxy from under the tape was necessary. The joints on Hydro-Ban RVN-45, transverse and longitudinal, had to be sealed in this manner. At this time, 12:30, the temperature of the span was 110°F in the sun and 106°F in the shade.

In the beginning, an approximate 12-inch width of concrete near the curb was left exposed while the membranes were being placed. These edges were covered last, with an additional width of membrane to

cover 3 to 4 inches of the curb and extend above the overlay material on the edges. Once the material was measured and a small cut made to mask the exact amount of membrane needed, the material tore very easily to the length that was needed. The covering of Span 11 with Hydro-Ban RVN-45 was completed at approximately 4:15.

Taping Hydro-Ban 531, a yellowish-brown liquid with a sand blend, was then placed over the membrane to provide texture and other advantages. This operation took approximately 55 minutes and much involved piece work.

On the morning of June 18, the maintenance crew made minor repairs to the Hydro-Ban RVN-45 membrane, putting additional epoxy on the longitudinal and transverse joints that had not bonded very well. They also cleaned the joints and placed filler in the epoxied joints. In the meantime, Concrete Research Unit personnel checked the resistivity readings on both membranes on Spans 10 and 11. Two sets of readings were taken on each membrane. Figure 4 below shows testing of System No. 5 (Hydro-Ban RVN-45) prior to the asphalt concrete overlay.

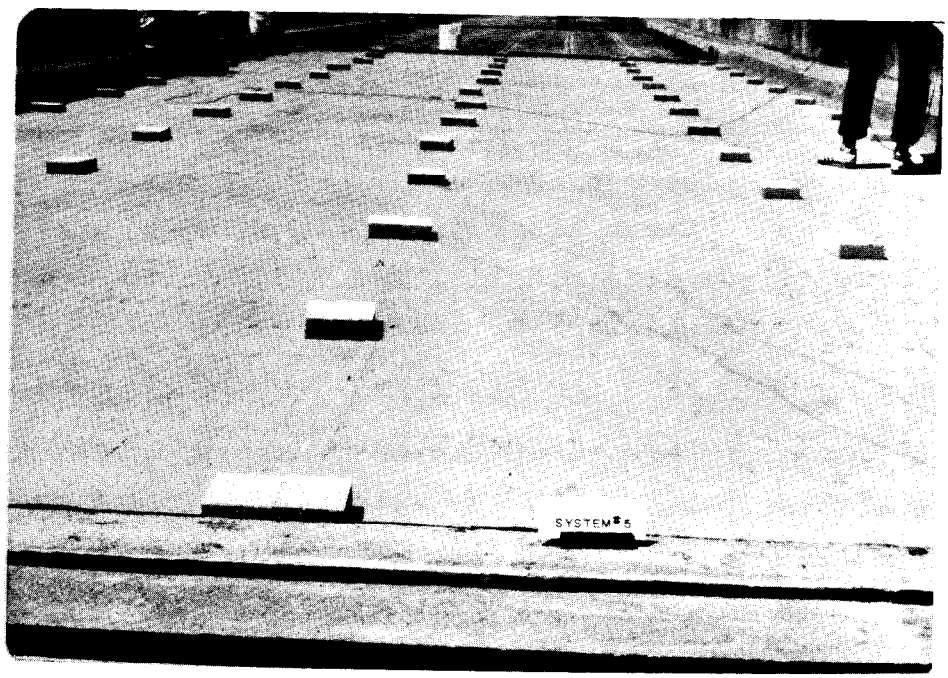

Figure 4
Testing System 5 (Hydro-Ban RVN-45)
Prior to Asphalt Concrete Overlay on Exit
Ramp in Monroe

A tack coat was applied to the east end of the Hydro-Ban RVN-45 membrane system approach slab for 20 feet for a tapered overlay to Span 11, with the same type of coverage being applied later to the west end.

The hot mix overlay consisted of a 9-ft. wide strip on the inside lane of the span. The temperature of the hot mix when it left the plant was 325°F. The temperature of the overlay surface was 260°F and the air temperature was 86°F. The Hydro-Ban RVN-45 system withstood traffic well while the overlay work was being completed.

Trapped air bubbles began appearing along an area in line, approximately 2½ to 3 feet away from the right curb in the Hydro-Ban RVN-45 system area. This area of the hot mix was spongy and some small cracking had formed. The rolling of the hot mix began over the area of overlay at 11:50.

Observations at 1:00 showed that trapped air bubbles appeared in the Hydro-Ban RVN-45 system areas at stations 35+00, 40+00 and 55+00. Small areas of the hot mix were removed, the membrane was cut approximately ½ inch in each area, and air was removed from under the membrane. These areas were patched with approximately 2 inch squares of membrane material and epoxied, then the areas were covered with hot mix. The final rolling on the hot mix followed.

Resistivity readings were taken the next morning, June 20, Observations showed that, due to the waterproofing membrane laid on the bottom left corner of Span 11, water was trapped and the bond of the hot mix to the membrane was questionable. Traffic was opened on the exit ramp at 8:45, but due to the light flow of small vehicles, no visible loss of bond was noticeable.

A hot mix overlay was applied the afternoon of July 1 for the second time on the Hydro-Ban span on the exit ramp off I-20 in Monroe. On July 2, resistivity readings were taken again on the exit ramp where the Hydro-Ban span was damaged during removal of the previous asphalt concrete overlay.

Figure 5 below shows a view of the asphalt concrete overlay on the exit ramp of I-20 in Monroe.

Figure 5
Asphalt Concrete Overlay on
Exit Ramp in Monroe

3. Bayou Lafourche Bridge,*I-20

On the afternoon of June 18, 1975 Concrete Research Unit personnel worked on Span 4 (eastbound) of the Bayou Lafourche Bridge, which was to be the reference span for the project. A permanent ground to the top mat steel in the bridge deck was established, then half-cell corrosion readings were taken, along with chloride samples from the bridge deck. These samples were submitted to the Materials Laboratory in Baton Rouge for testing. The temperature was a humid 92°F.

During the week of June 23-27 maintenance forces worked to prepare the (left bridge, westbound, both lanes) spans of the Bayou Lafourche Bridge for the application of the membranes. Work consisted of installing epoxy and transflex joints, along with preparing the bridge deck surface.

a. System 1 (Superseal 4000 Low Heat) - System No. 1 was installed in both lanes of the left bridge (westbound) on Spans 1 and 2. Installation began June 27 in the inside traffic lane with the company representative present. Span 2 was covered first. Application lasted from 10:05 to 10:40 a.m. The material was applied the same as on the exit ramp off I-20 at Monroe. Figure 6 on the following page shows the application of System No. 1.

For Span 1, more material was heated at a temperature of 260°F. Pouring lasted from 12:30 to 1:00 P.M. The membrane was applied 90 ml. thick at a rate of 2 square yards per gallon of material. The membrane was heated by a 120-gallon double boiler with oil bath heat transfer.

*NOTE: The report format for the Installation Procedures and Field Problems is in the form of a listing by systems and a discussion of each system installation. The installation procedures are not necessarily in order by date or sequence. Some procedure reporting may be repeated for various systems.

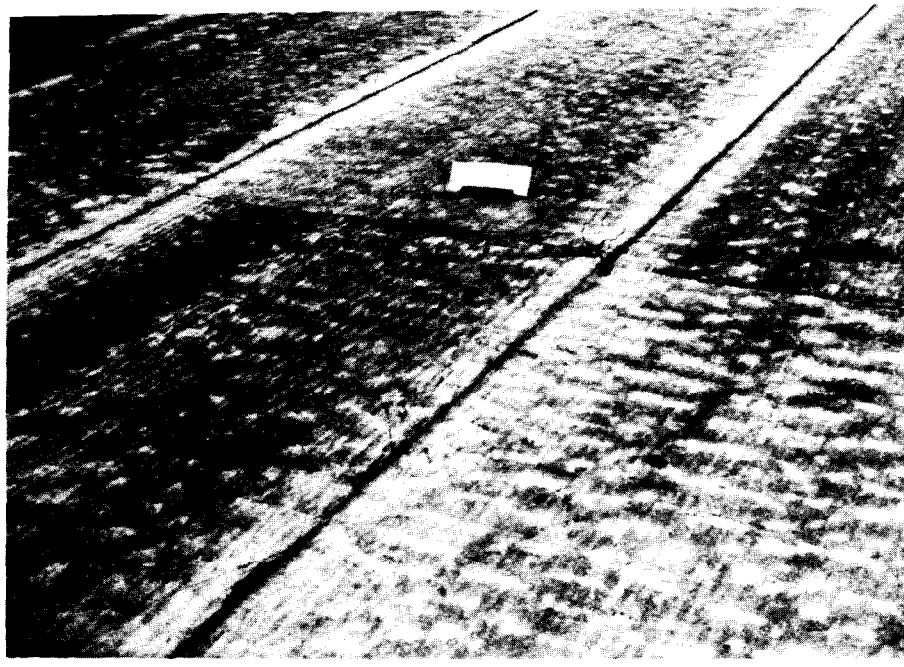

Figure 6
System No. 1 (Superseal 4000)
Application

Overlay of the inside westbound lane of Spans 1 and 2 of the Bayou Lafourche Bridge on I-20 was accomplished on July 1, 1975.

System 1 (Superseal 4000) was installed on Spans 1 and 2, again in the outside westbound traffic lane of the left bridge. Spreading of Superseal 4000 began July 9, 1975 at 8:00. Installation began at 9:50 with the completion of Span 2 at 10:25 and Span 1 at 11:15. Resistivity readings were completed at 1:15.

Prior to the overlay, the Concrete Research Unit personnel placed 1 foot square aluminum panels (0.032 inches in thickness) wired with insulated double strand 24-gauge wire leads 5 feet long on the surface of each membrane on each bridge span at Station 55 + 00. These plates were centered 14 inches off the curb in the outside roadway opposite a bridge drain, so that the leads could be extended into the drain and not cover the ends of the wire during the overlay. The purpose of these plates was to determine the resistivity and time of water penetration of hot mix overlay for calculation and use in future testing. The plates were placed on the membranes and the edges epoxied to hold them in place when the overlay was put down. The curing time of the epoxy was 15 minutes and these installations were completed at 9:00.

The overlay began July 14, 1975 on the slab at the end of Span 9 and continued through the approach slab at the beginning of Span 1. Rolling began on the edges of both the old and new hot mix. Rolling on the new hot mix began at 9:50. A very light tack coat was placed on the Superseal 4000 membrane, Spans 1 and 2. However, this tack coat was missing completely from Station 52 + 00 to Station 60 + 00 on Span 2. The temperature behind the paver on the hot mix at 9:40 was 224°F. There was some light cracking of the 65-lb. felt paper during paving on Spans 1 and 2.

The aluminum panels were checked at several spans to determine water penetration and time. Resistivity readings on Spans 1 through 6 were begun at 6:30 July 16 and completed at 11:45.

Both lanes of the Bayou Lafourche Bridge were opened to traffic at 1:45, July 16. At this point, operations on this experimental installation and research project were complete. Laboratory evaluation work continued, as did resistivity readings. These readings, however, will be treated in a following section.

b. System 2 (Hydro-Ban RVN-30) and System 5 (Hydro-Ban RVN-45)- System No. 2 on Span 3 and System No. 5 on Span 4 were installed in both lanes of each respective span as noted. The company representative was present for part of the application of System No. 2. Application of the epoxy primer to Spans 3 and 4 began at 9:55, June 26, 1975. The membrane application to Span 4 began at 10:10 on the inside lane. The same operation was used as that on Span 11 of the exit ramp off I-20 in Monroe, which included butting and epoxying the joints, using the 1-inch tape, and working the membrane on the edges of the curb. The taping operation was completed on both spans at 4:35. Figures 7-9 following show Systems 2 and 5 being applied.

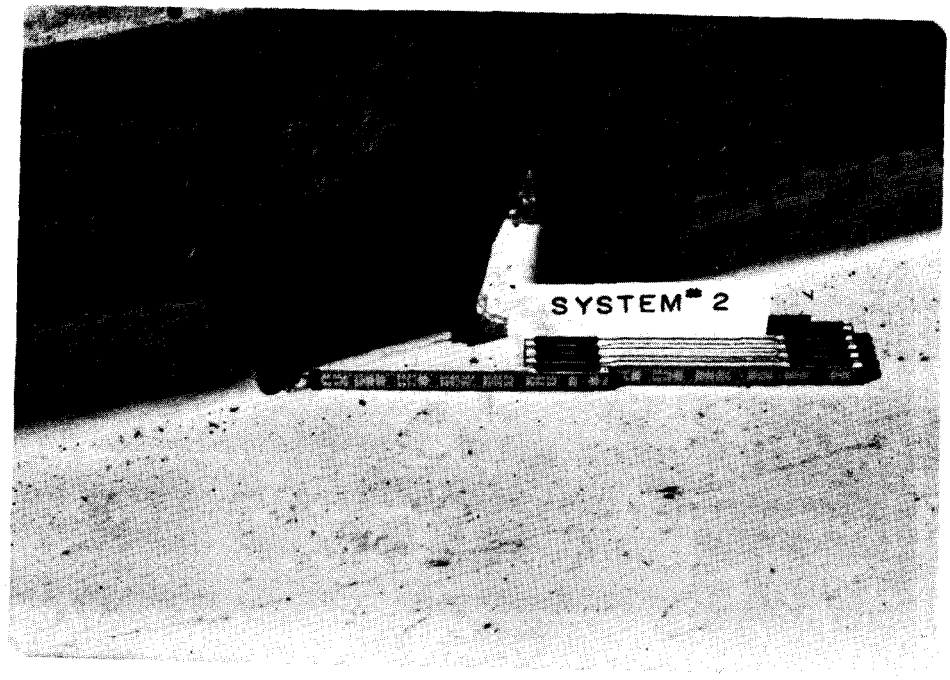

Figure 7
System No. 2 (Hydro-Ban RVN-30)
Curb Application

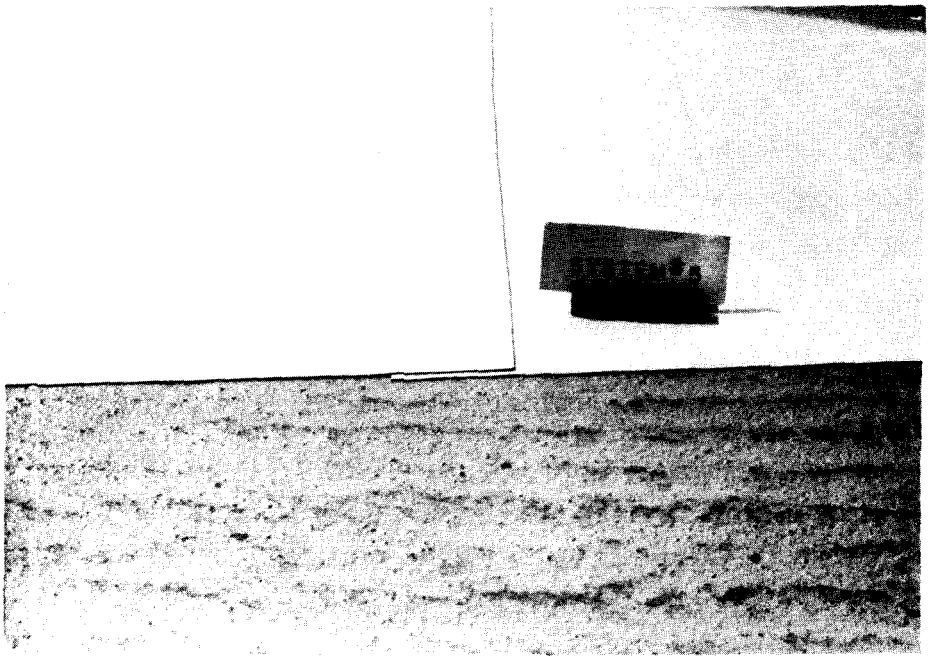

Figure 8
System No. 5 (Hydro-Ban RVN-45)
Overlapping

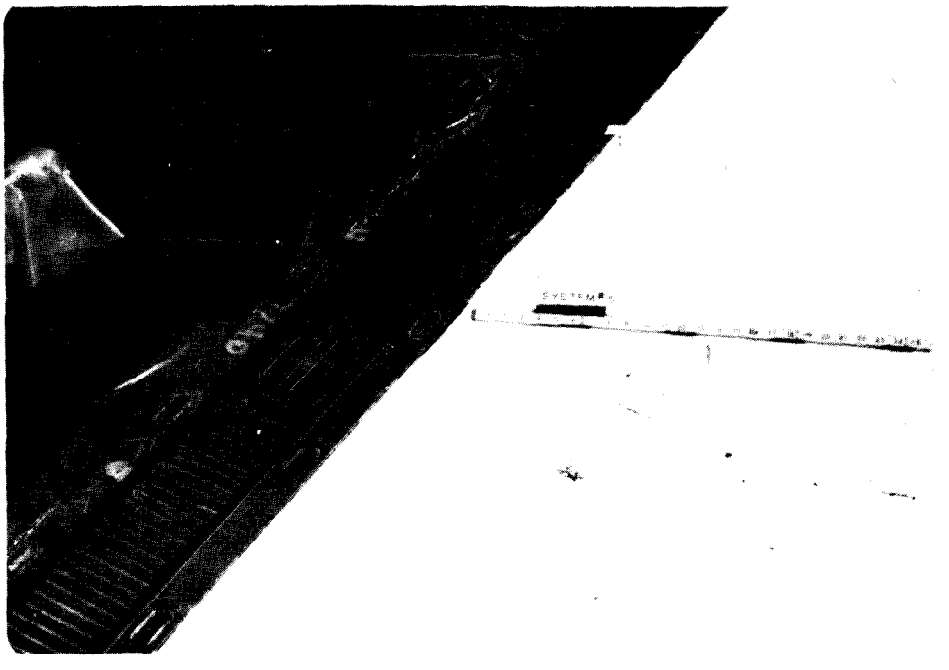

Figure 9
System No. 5 (Hydro-Ban RVN-45)
Next to Transflex Joint

On June 27, all resistivity readings taken on the Hydro-Ban RVN-45 and Hydro-Ban RVN-30 system membranes were good, registering in the million ohms. Figure 10 below shows resistivity connections to the bridge steel needed for good readings.

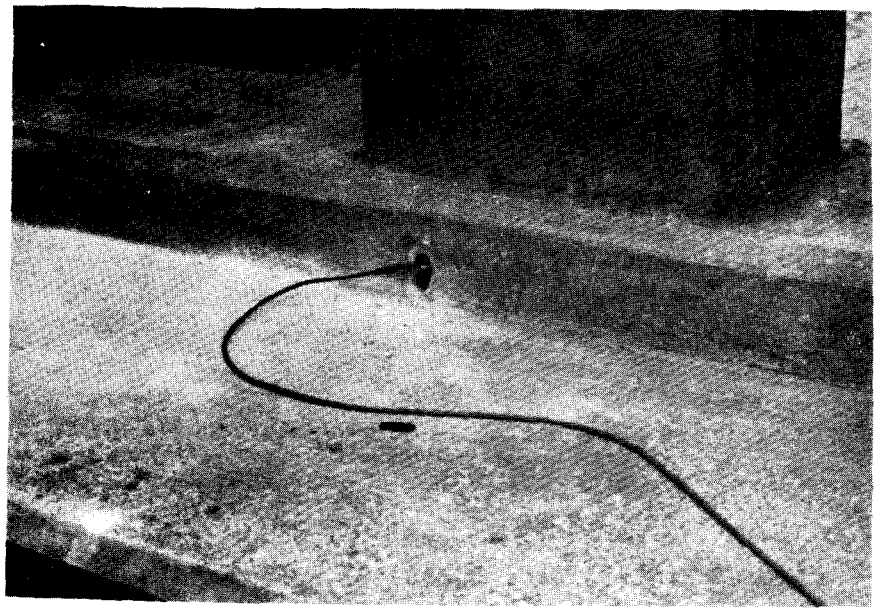

Figure 10
Connection to Bridge steel
for Resistivity Readings

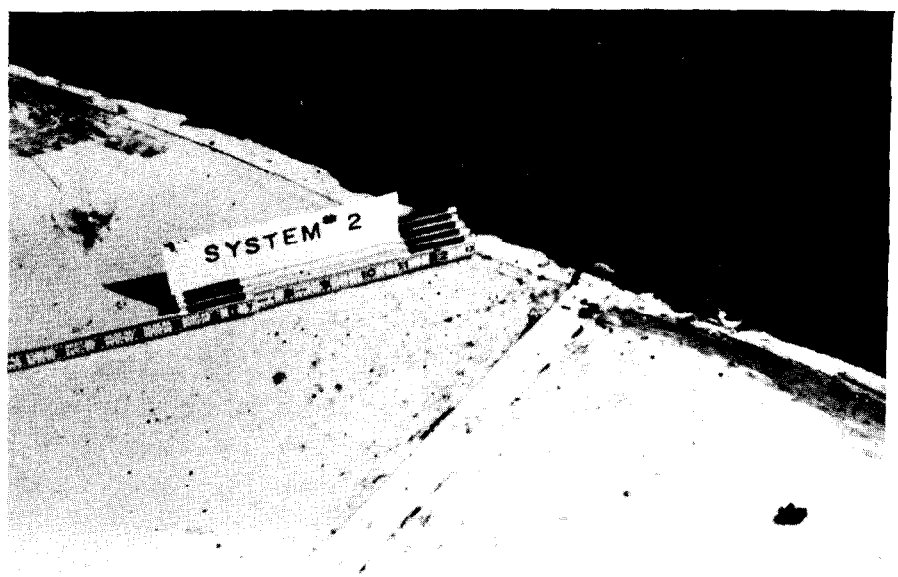

Figure 11
System No. 2 (Hydro-Ban RVN-30) Application

Installation of two widths of System 2 (Hydro-Ban RVN-30) on Span 3 began at 4:00 Figure 11 on the preceding page shows this application next to the overlay.

Installation of the membrane systems on the outside lane (westbound) of the left bridge on I-20 at Bayou Lafourche, began July 9. The first installation was System 5 (Hydro-Ban RVN-45) on Span 4. Note that a primer or epoxy was applied the width of each roll used for the length of the span on System 5. The epoxy was left to cure and the Hydro-Ban was rolled out and applied. Heavy rain began at 4:30 and work was discontinued for the day.

On July 10, it was discovered that, due to improper sealing and heavy rain the day before, the two rows of System 2 (Hydro-Ban RVN-30) on Span 3 experienced water seepage. At this point, approximately 20 feet on each row was removed and replaced. The remaining membrane was lapped back approximately one foot on each side, dried, reprimed and laid back on the concrete surface. The remaining surface of Span 3 was covered and taped, and operations were completed at 1:10. System 5 (Hydro-Ban RVN-45) was also resealed on the edges of the centerline of the roadway.

Resistivity readings were taken on Systems 2 and 5 (Hydro-Ban RVN-30 and 45), however heavy rains began at 3:15 and work was discontinued for the day. Later all necessary resistivity readings were taken.

On July 14, preliminary work began prior to overlay. The Hydro-Ban liquid topping was placed on the surface of the membrane beginning at 4:05 and was completed at 5:00. No topping was applied from Station 0+00 to Station 25+00 on Span 4 in the outside lane.

Application of the Hydro-Ban mastic to the surface of the membrane

on Spans 3 and 4 began at 7:00 a.m., July 15 and was completed at 7:40. Ten gallons of mastic were used, and a quart of gasoline was used to thin out the material. The mastic material served as a tack coat prior to overlay. The contractor's crew sprayed a tack coat on the Hydro-Ban spans and on either side of the bridge.

As described in the previous section on System 1, prior to the overlay, the Concrete Research Unit personnel placed 1-foot square aluminum panels (0.032 inches in thickness) wired with insulated double strand 24-gauge wire leads 5 feet long on the surface of each membrane on each bridge span at Station 55+00. The purpose of these plates was to determine the resistivity and time of water penetration of the hot mix overlay for calculation and use in future testing.

The overlay began on the slab at the end of Span 9 and continued through the approach slab at the beginning of Span 1.

As noted before, rolling began on the edges of both the old and new hot mix. When the trucks drove on the Hydro-Ban RVN-45, the mastic began sticking to the wheels and some of the membrane in the wheel paths were removed, the worst being on Span 4 from Station 45+00 to Station 60+00. Rolling on the new hot mix began at 9:50.

Repeating, the aluminum panels were checked at several spans to determine water penetration and time. Resistivity readings on Spans 1 through 6 were begun at 6:30, July 16 and completed at 11.45. Both lanes of the Bayou Lafourche Bridge were opened to traffic at 1:45, July 16. At this point, operations on this experimental installation and research project were complete. Laboratory evaluation work continued as did resistivity readings. These readings, however, will be treated in a following section.

c. System 3 (Protecto Wrap)--This system was installed on Spans 5 and 6. Again installation began in the inside lane with the company representative present. Application of the No. 80 Protecto Wrap primer bagan at 1:40, June 25, 1975 as the material was poured from 5-gallon cans onto the deck and spread with a squeegy. This was completed at 2:10. Small air bubbles formed in the primer as it cured. The temperature of the regular concrete surface was 124°F while that of the primer was 131°F.

Figure 12 below shows the application of primer onto the bridge deck.

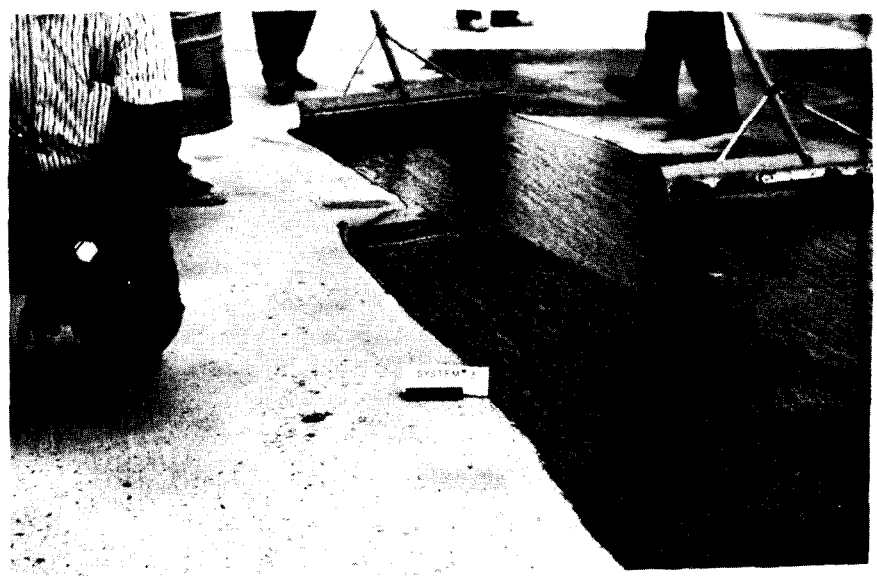

Figure 12
Application of Protecto Wrap Primer

Membrane application began at 3:00 June 25 along the curb with a 30-inch wide piece of membrane and lapped up onto the curb approximately 2½ inches. Both spans were covered at the same time, as was the expansion joint between the spans. The remaining membrane was 4 by 50-feet. Each roll of membrane overlapped the other 4 inches and also overlapped the spliced joints. The existing membrane, once in place, retained a protective covering of plastic paper, so that the surface could be kept clean before the P-100 topping was applied. Prior to hot mix application, the paper was removed and the P-100 placed over this membrane. This application was completed at 4:35. Note that some edges along the curb and joints were sealed with a C-8104 Protective Mastic, but due to rain, the sealing could not be completed.

Light rain occurred at 4:45 followed by a hard rain at 4:55. During the night, kerosene flares were knocked over, damaging some areas of the membrane. Also, because all edges had not been sealed, water became entrapped under the edges of the membrane. The edges had to be lapped back, dried out and resealed to the concrete.

The following table shows the areas of the membranes that had to be removed and patched:

Table 2

Protecto Wrap M-400

Patch Areas

Span 5, Inside Lane, Left Bridge

Station	Distance from Curb	Area of Patch
26+00	Began at Curb	14.6' Long, 37" Wide
30+00	10' Left of Curb	6.0' Long, 47" Wide
54+00	10' Left of Curb	12.0' Long, 48" Wide
57+00	5' Left of Curb	5.0' Long, 33" Wide
54+00	Began at Curb	6.5' Long, 36" Wide
	Span 6, Inside Lane, Left Bridge	
2+00	5' Left of Curb	3.0' Long, 18" Wide
0+00	Began at Curb	3.5" Long, 36" Wide
16+00	10.5' Left of Curb	6.0' Long, 42" Wide

Patching of the areas was completed at 3:15 on June 26, 1975. Resistivity readings could not be taken until after the P-100 was applied.

Figure 13 below shows a patch area for Protecto Wrap.

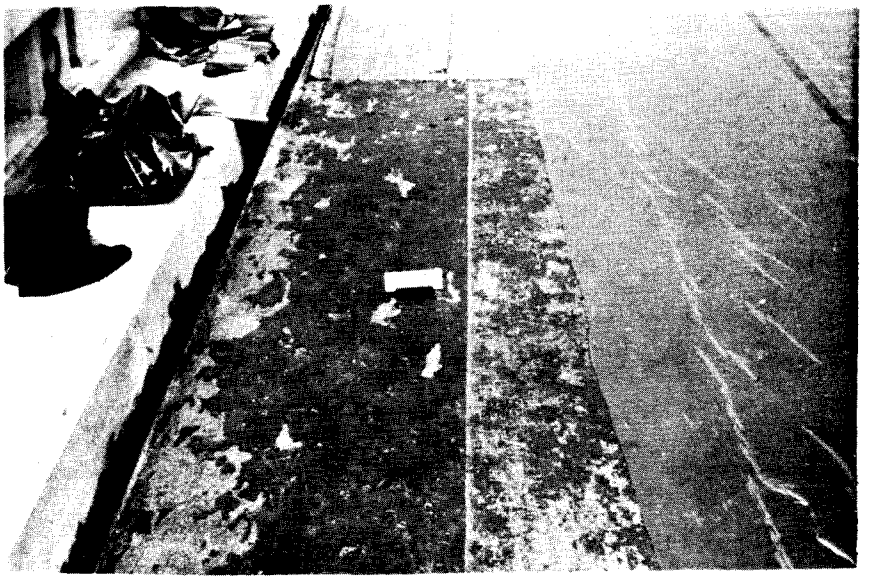

Figure 13
Protecto Wrap Patch Area

On June 30, the bridge crew started applying the P-100 board on the Protecto Wrap at 1:30 and finished at 4:00. Some areas on the membrane where the protection sheet came off had to be cleaned and reprimed. The rolls of P-100 board were very irregular on the ends and split in some areas. Except for this, the application went smoothly.

On July 1 preliminary resistivity readings were made on the Protecto-Wrap membrane, System No. 3. The bridge crew made minor repairs to the membrane and cleaned the surface on the inside lane.

The first load of hot mix arrived at 10:20 and laydown operations began at 10:30. The temperature of the mix was 320^{o}F. The hot mix was put down in the direction of traffic on the inside lane, beginning on Span 9. The first truck had 30,000 pounds of hot mix which went

to Span 8, at station 35 + 00. The second truck had 26,045 pounds which went to Span 6, at station 25 + 00. At this point, it was discovered that the first two trucks had a slag plant mix seal and not the crushed granite expected. The plant was contacted and the correction was made. The slag plant mix seal was therefore placed on spans of Systems 3, 4 and 6 on the inside lane. Figure 14 shows the asphalt concrete overlay with both the slab plant mix seal and the crushed granite.

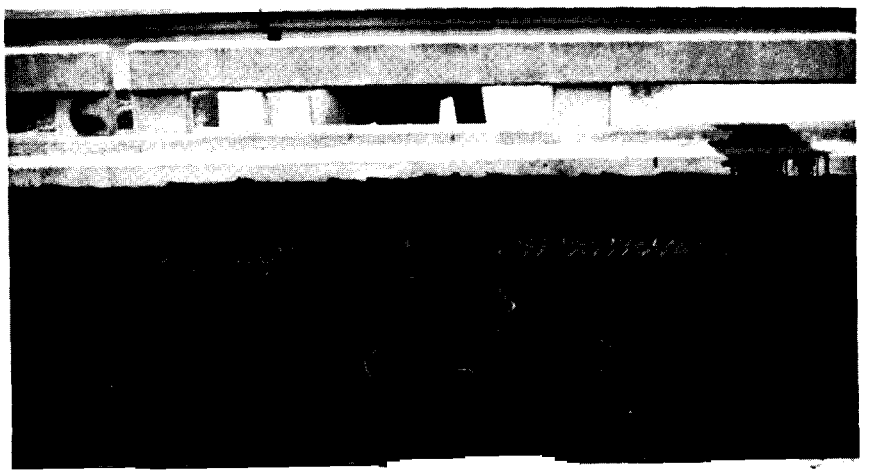

Figure 14
Asphalt Concrete Overlay with Slag Plant
Mix Seal Next to Crushed Granite Mix

Hot mix rolling began at 10:50. The felt paper experienced some tearing because of the spreader, but was not damaged enough to be removed. The overlay was completed at 12:30. After the hot mix cooled, resistivity readings were taken. This completed installation of membranes and overlay on these spans on the inside lane of the left bridge on I-20 at Bayou Lafourche. Figure 15 shows the asphalt concrete overlay in the inside westbound lane of the Bayou Lafourche Bridge.

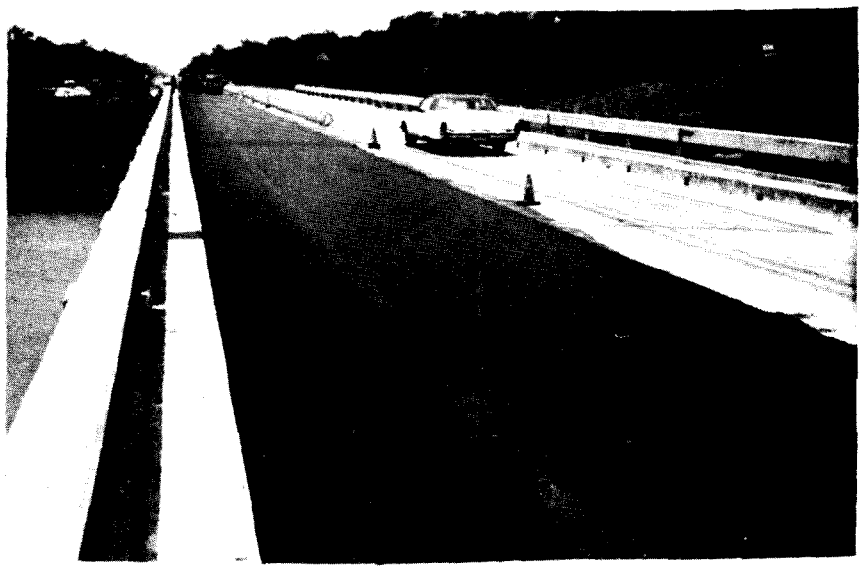

Figure 15
Asphalt Concrete Overlay on Inside Westbound
Lane of the Bayou Lafourche Bridge

Installation of the membrane systems on the outside lane (westbound) of the left bridge on I-20 at Bayou Lafourche began July 9. One of the first installations was System 3 (Protecto Wrap) on Spans 5 and 6.

System 3 (Protecto Wrap M-400) was installed on Spans 5 and 6 with the company representative present. Both spans were covered with primer at 11:00 and the membrane was placed beginning at 12:55 with a 12-inch strip near the curb side, lapping up approximately 3 inches. Tiny bubbles formed in the primer as it cured.

The membrane placement was completed at 2:50 and a black mastic was placed on the membrane at the centerline edge, joints and curb edges. The temperature of the concrete on the bridge deck was 120°F at 1:30 and 122°F at 2:00. Installation and taping was completed at 3:30.

On July 14 preliminary work began prior to overlay. Protecto Wrap P-100 protective board was placed on Spans 5 and 6 from 12:30 until 1:45. As stated before, at this time, Concrete Research Unit personnel placed the 1-foot square aluminum panels with insulated wire leads on the surface of the bridge spans for purposes of determining the resistivity and time of water penetration of the overlay.

The overlay began July 14 on the slab at the end of Span 9 and continued through the approach slab at the beginning of Span 1. Rolling began on the edges of both the old and new hot mix.

As stated before, the aluminum panels were checked at several spans to determine water penetration and time. Resistivity readings on Spans 1 through 6 were begun at 6:30 July 16 and completed at 11:45. Both lanes of the Bayou Lafourche Bridge were opened to traffic at 1:45 July 16. At this point all operations on this experimental installation and research project were complete. Laboratory evaluation work continued, as did resistivity readings. These readings, however, will be treated in a following section.

d. System 4 (Heavy Duty Bituthene) -- This system was installed on Spans 7 and 8 on June 25, 1975. Installation began in the inside traffic lane, with company representative present. A primer was applied to the concrete deck with paint rollers and small bubbles formed in the primer while it cured. The Heavy Duty Bituthene membrane was applied on Span 7 from the Transflex joint to the end of Span 8. Curb side application consisted of a 12-inch strip of membrane, extending up the curb side approximately 2½ inches.

The deck had been measured and chalk-lined for the membrane to be laid where the material could be overlapped with each layer at least 2 inches wide. The material was in 60-ft. lengths on rolls 30 inches wide and had to be removed as the membrane was placed on the deck.

Figure 16 below shows the application of the membrane.

Figure 16
Rolling Heavy Duty Bituthene
Membrane onto Slab

A black bituthene mastic was applied to the top edge of the membrane on the curb, at the centerline of the roadway where the membrane ended, and at the expansion joints.

During the night of June 25 traffic knocked kerosene flares over onto some areas of the membrane, which according to the company representative, remained undamaged. Good resistivity readings had been taken on both spans that morning.

Overlay of the inside westbound lane began July 1 with the first load of hot mix arriving at 10:20 and the laydown operations beginning at 10:30. The temperature of the mix was 320°F. The hot mix was put down in the direction of traffic, beginning on Span 9 with the first truck going to Span 8, at station 35 + 00. The second truck went to Span 6, at Station 25 + 00. As stated previously in the System 3 section, at this point, it was discovered the first two trucks had a slag plant mix seal and not the crushed granite expected. The plant was contacted and the correction was made. Hot mix rolling began at 10:50 with the overlay being completed at 12:30.

After the hot mix cooled, resistivity readings were taken on the Bayou Lafourche Bridge. This completed installation of membranes and overlay on Spans 7 and 8 on the inside lane of the left bridge on I-20 at Bayou Lafourche.

Installation of the membrane systems on the outside westbound lane of the left bridge on I-20 at Bayou Lafourche began July 9, 1975. System 4 (Heavy Duty Bituthene) was installed on Spans 7 and 8 in the outside westbound lane of the left bridge at Bayou Lafourche. Placement of the primer began at 10:40 and that of the membrane began at 11:20. Here, the membrane was cut in lengths at approximately 12-by 15-feet and placed, overlapping the edges of each membrane previously laid approximately 3 inches wide. This installation method was considerably better because no wrinkles were made in the membrane. The company representative was present and operations were completed at 1:45. It was noted July 11 that on Spans 7 and 8 (Heavy Duty Bituthene), as well as Span 9 (Royston), water had been trapped on the deck. The deck had to be squeegyed and an air compressor used to blow off the remaining water, before resistivity readings could be taken.

On July 14 preliminary work began prior to overlay. At this time, Concrete Research Unit personnel placed the 1-foot square aluminum panels with insulated wire leads on the surface of the bridge spans

for purposes of determining the resistivity and time of water penetration of the overlay.

The overlay on the outside westbound lane began on the slab at the end of Span 9 and continued through the approach slab at the beginning of Span 1. Rolling began on the edges of both the old and new hot mix.

The aluminum panels were checked at several spans to determine water penetration and time. Resistivity readings on Spans 1 through 6 were begun at 6:30 July 16 and completed at 11:45. Both lanes of the Bayou Lafourche Bridge were opened to traffic at 1:45 July 16. At this point, all operations on this experimental installation and research project were complete. Laboratory evaluation work continued, as did resistivity readings. These readings, however, will be treated in a following section.

e. System 6 (Royston) -- System No. 6 was installed on Span 9. Work began June 27, 1975 in the inside lane with the company representative present to direct the proper application of the membrane. The primer was applied to the surface of the deck between 9:00 and 9:30 a.m. Membrane placement began at 10:15 and was completed at 11:15. Figure 17 following shows System No. 6 application.

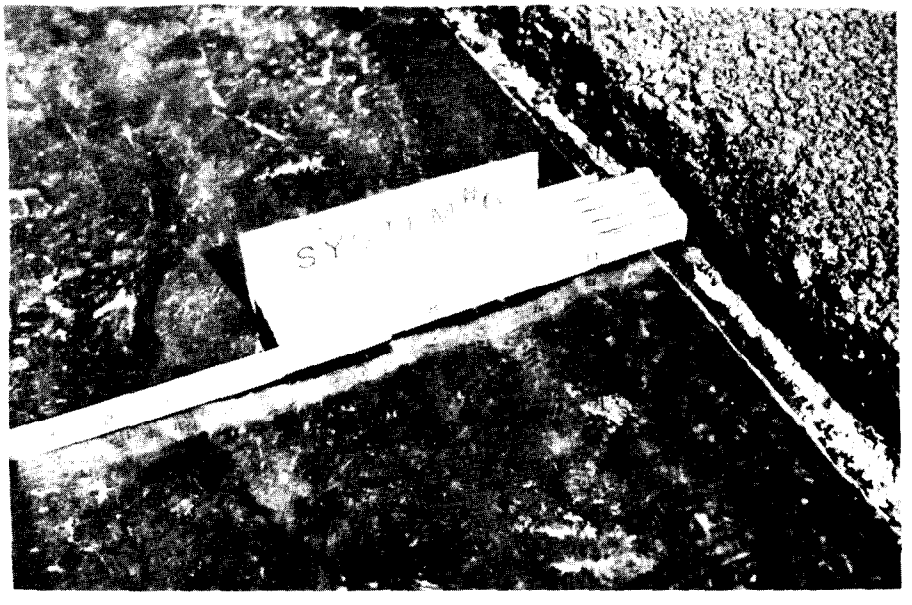

Figure 17
System No. 6 (Royston)
Application

The 4-by 50-foot rolls overlapped each other approximately 3 inches. After application of the membrane, the 3-inch lap up the curb edge was heated with a torch, as were the joints, for a good bond to the concrete deck. As this was the last span on the bridge, the material butted against an epoxy joint of epoxy and sand. Resistivity readings were taken the next week before the hot mix overlay was placed.

Overlay operations began on the inside westbound lane at 10:20 on July 1 when the first load of hit mix arrived. Laydown operations began at 10:30, with the temperature of the mix being 320°F. The hot mix was put down in the direction of traffic, beginning on Span 9. It was discovered, after the first two trucks arrived, that a slag plant mix seal had been placed instead of the expected crushed granite. The plant was contacted and the correlation was made. Hot mix rolling began at 10:50 with the overlay being completed at 12:30.

After the hot mix cooled, resistivity readings were taken on the Bayou Lafourche Bridge. This completed installation of membrane and overlay on Span 9 on the inside lane of the left bridge on I-20 at Bayou Lafourche.

Installation of the membrane systems on the outside lane (westbound) of the left bridge on I-20 at Bayou Lafourche began July 9. Figure 18 below shows System 6 (Royston) and its application.

Figure 18
System No. 6 (Royston)
Application

With the company representative present, System 6 (Royston No. 10) was installed on Span 9. Placement of the primer began at 11:10 and was completed at 11:30, and membrane placement began at 12:40 and ended at 2:00. Note that the membrane was placed the same as in the other traffic lane.

As stated before, it was noted July 11 that on Span 9 (Royston), as well as Spans 7 and 8 (Heavy Duty Bituthene), water had been trapped on the decks. The decks had to be squeegyed and an air compressor used to blow off the remaining water, before resistivity readings could be taken.

On July 14 preliminary work began prior to overlay. At this time, Concrete Research Unit personnel placed 1-foot square aluminum panels with insulated wire leads on the surface of the bridge spans for purposes of determining the resistivity and time of water penetration of the overlay.

The overlay began on the slab at the end of Span 9 and continued through the approach slab at the beginning of Span 1. Rolling began on the edges of both the old and new hot mix.

The aluminum panels were checked at several spans to determine water penetration and time. Resistivity readings on Spans 1 through 6 were begun at 6:30, July 16 and completed at 11:45. Both lanes of the Bayou Lafourche Bridge were opened to traffic at 1:45, July 16. At this point, all operations on this experimental installation and research project were complete. Laboratory evaluation work continued, as did resistivity readings. These readings, however, will be treated in a following section.

DISCUSSION OF RESULTS

This research project has produced results considered inconsistent in one sense and predictable in another. The field evaluation phase of the study was considered to be inconsistent because a majority of the results found in the laboratory phase did not agree with the field results, however, the field results were somewhat predictable because of problems encountered in the field and with the construction methods.

A. Laboratory Test Results-

Tables 3, 4 and 5 on the following pages summarize the various test results from the laboratory phase of the study. Test methods are described in the Methodology.

As one can see, four of the six membrane systems passed the laboratory tests and appeared promising for trial use in the field as waterproofing materials on concrete bridge decks. In the laboratory, System No. 6 (Royston) never achieved a good bond, or any bond, to the concrete blocks used for the tension tests, resulting in the inability to get resistivity readings. Thus, a failure was recorded. System No. 1 (Superseal 4000) developed cracking or breaking, both on the bond test at $-5^{o}F$ and at all temperatures ($+10^{o}$, $+5^{o}$, 0^{o} and $-5^{o}F$) for the heat-aged bend tests. This same system also failed on the resistivity readings after the tension test at $-5^{o}F$. Except for these specific instances, membrane system Numbers 2, 3, 4 and 5 passed most of the tests and looked promising enough, at least from results in the laboratory, to be considered for field trials on a concrete bridge deck.

However, because comparisons were desired, all of the membrane systems (Numbers 1, 2, 3, 4, 5 and 6) were installed on bridges in the field for testing and evaluation and are discussed in the next section of the report.

Table 3
Summary of Bend Test Results

Syster No.	Name of Product		+10°F	+5°F	0°F	-5°F
1	Superseal 4000	High Heat	No Damage	No Damage	No Damage	Failure, 5 of 5 broke
		Low Heat	No Damage	No Damage	No Damage	Failure, 5 of 5 broke
2	Hydro Ban RVN-30		No Damage	No Damage	No Damage	No Damage
3	Protecto Wrap		No Damage	No Damage	No Damage	No Damage
4	Heavy Duty Bituthene		No Damage	No Damage	No Damage	No Damage
5	Hydro Ban RVN-45		No Damage	No Damage	No Damage	No Damage
6	Royston		Failure, No Bonding	Failure, No Bonding	Failure, No Bonding	Failure, No Bonding

*Note: Failure was recorded when specimen either broke apart or cracked

Table 4
Summary of Heat-Aged Bend Test Results

System No.	Name of Product		+10°F	+05°F	0°F	-5°F
1	Superseal 4000	High Heat	1 of 5 broke	5 of 5 broke	5 of 5 broke	5 of 5 broke
		Low Heat	5 of 5 broke	5 of 5 broke	5 of 5 broke	5 of 5 broke
2	Hydro-Ban RVN-30		No Damage	No Damage	No Damage	3 of 5 broke
3	Protecto Wrap		No Damage	No Damage	2 of 5 orig. topside broke	No Damage
4	Heavy Duty Bituthene		No Damage	No Damage	No Damage	No Damage
5	Hydro-Ban RVN-45		No Damage	No Damage	No Damage	No Damage
6	Royston		Failure, No Bonding	Failure, No Bonding	Failure, No Bonding	Failure, No Bonding

*Note: Failure was recorded when specimen either broke apart or cracked.

Table 5
Summary of Resistivity Readings
Before and After Tension Tests

System No.	Name of Product		+10°F Before	+10°F After	+5°F Before	+5°F After	0°F Before	0°F After	-5°F Before	-5°F After
1	Superseal 4000	High Heat	42M	330M	50M	448M	42M	5-Fail	93M	5-Fail
		Low Heat	159M	500M	64M	440M 2-Fail	1208M	Inf 1 Fail	118M	272M 2-fail
2	Hydro-Ban RVN-30		Inf	Inf	350M	Inf	Inf	Inf	Inf	Inf
3	Protecto Wrap		Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf
4	Heavy Duty Bituthene		Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf
5	Hydro-Ban RVN-45		Inf	Inf	Inf	Inf	Inf	Inf	Inf	Inf
6	Royston		Failure, No Bonding		Failure, No Bonding		Failure, No Bonding		Failure, No Bonding	

*Note: Units of Measure are Ohms resistance. M = Million.
Failure in the laboratory was recorded
when resistance reading was below 500,000 ohms

B. Field Evaluation and Test Results-

There were several types of field evaluations made, among which were resistivity readings for determining waterproofing ability, overlay and safety considerations and visual observations. Other states and agencies have reported various results and made specific recommendations. This report, however, concerns what has occurred in this state, and consequently actions taken and determination made because of these occurences.

As stated in an FHWA Notice on Interim Report (4), NEEP No. 12:

> With reasonable care in following recommended installation procedures during construction, reports show a significant number of states are satisfied with their use of the Heavy Duty Bituthene and Protecto Wrap systems. These two waterproofing systems are no longer considered experimental. One of the important things not known about any of the membrane systems is their long term performance under heavy traffic. Liquid membranes applied by spraying or use of a squeegy have always appeared attractive because of their simplicity and ease of application. These liquid applied systems, however, have been plagued by blistering, pinholing, cratering, temperature susceptability, and tenderness under construction traffic which have contributed to poor impermeability characteristics.

These statements are true enough, however, in this state, success has not materialized, even with Heavy Duty Bituthene or Protecto Wrap systems.

Although not the only criteria used, California's recommended procedure of accepting membrane systems by passing a 250,000 ohms per square foot resistivity test in the field was generally followed in this Louisiana study. At the last field evaluation and test period, none of the six membrane systems placed on the Bayou Lafourche Bridge passed the resistivity test and all were recorded

as failures. Previous test periods also had indicated the same results, as far as resistivity readings were concerned. Thus, poor impermeability characteristics seem to have been exhibited on all these systems and resulted in their failure.

Various problems existed in the field on some of the test spans. A construction problem encountered was the damage occurring to the membrane system during application of the hot bituminous pavement overlay even with a protective layer between the membrane and the overlay. Primarily the local construction traffic hot mix trucks, paver and related equipment showed a tendency to damage the membranes. These problems were discussed in detail in the Installation Section and will be listed only briefly here. Several overlay sections, including the underlying membrane, had to be removed because parts of the overlay were becoming a safety problem.

C. Installation Problems-

Following is a brief description of some problems encountered:

Exit Ramp-System 1 (Superseal 4000) on Span 10: When loaded trucks began braking to a stop, the felt paper began tearing and slid forward 10 to 15 inches.

System 5 (Hydro-Ban RVN-45) on Span 11: The joints needed additional epoxy for bonding to occur. Trapped air bubbles and small cracking appeared. Small areas of hot mix were removed and the membrane cut and redone. A new overlay was placed on this span July 1.

Bayou Lafourche Bridge

System 1 (Superseal 4000) on Spans 1-2: No obvious problems.
System 2 (Hydro-Ban RVN- 30) on Span 3 - Heavy rains

caused water to get under the membrane, 20 feet of which was replaced. Eventually the system on this span had to be replaced because of a lack of bond with the overlay.

System 3 (Protecto Wrap) on Spans 5-6: Air bubbles appeared in the primer. Water from heavy rains was trapped under the edges of the membrane, the edges were lapped back, dried out, and resealed to the concrete surface. Joint spalling occurred as shown in Figure 19.

System 4 (Heavy Duty Bituthene) on Spans 7-8: Small air bubbles appeared in the primer. Joint spalling occurred as shown in Figure 20. Spalling and potholes resulted in patching of the hot mix on both spans, with span 8 having more damage, as shown in Figures 21 and 22. Shoving of these patches and the asphalt in the outside lane caused some safety problems. Since the last evaluation, the hot mix overlay and membrane systems were removed from these spans and a new overlay placed.

System 5 (Hydro-Ban RVN-45) on Span 4: The mastic stuck to the wheels of the hot mix trucks and some of the membrane in the wheel path was removed. Eventually this membrane was removed and replaced because of a lack of bond with the overlay.

System 6 (Royston) on Span 9: No obvious problem.

Slag plant mix seal was placed mistakenly as the overlay material on the inside lane of Spans 7, 8 and 9 (Systems 4 and 6, Heavy Duty Bituthene and Royston). Generally this material appeared in good condition. However, evaluation was not easy where comparisons were made of the membrane material performances. As stated before, low resistivity readings indicate poor impermeability chacteristics for all membrane systems evaluated, thus failure must be recorded for each system.

Generally speaking, the low resistivity readings have been a disappointment primarily because they occurred on all the membrane systems, resulting in making it difficult to compare any of the systems except as to installation and overlay capabilities. A FHWA Notice (5) NEEP No. 12 stated resistivity test is questionable on the grounds of complete accuracy and repeatability. However, it is invaluable as an indicator of potential problems, and study results show ultimately the membrane systems evaluated herein were ineffective in completely waterproofing this concrete bridge deck.

CONCLUSIONS

The objective of this study was to determine the effectiveness of certain concrete bridge deck waterproofing membrane systems evaluated under conditions prevailing in Louisiana. The primary conclusion reached herein was that, using electrical resistivity readings as the chief test for waterproofing ability, all systems evaluated in the field failed to achieve total impermeability of the concrete deck.

Other conclusions reached were: (1) two membrane systems, Nos. 1 and 6 (Superseal 4000 and Royston) failed tests in the laboratory, (2) Nos. 2, 3, 4 and 5 (Hydro-Ban RVN-30, Protecto Wrap, Heavy Duty Bituthene and Hydro-Ban RVN-45) generally passed the laboratory tests and looked promising for further field tests, (3) although some systems pass laboratory tests, it doesn't mean that these systems would be successful in the field, (4) difficulty was encountered in the field on the exit ramp of I-20 in Monroe, where some slipping of the overlay was evident and some overlay had to be removed and replaced, (5) System No. 4 (Heavy Duty Bituthene) on Spans 7 and 8 off the Lafourche Bridge had the most overlay problems, especially in the outside traffic lane where severe shoving occurred, precipitating a minor safety problem (the overlay on these two spans had to be removed and replaced), (6) Nos. 2 and 5 (Hydro-Ban RVN-45) on Spans 3 and 4 had to be removed with the overlay due to bonding trouble between the membranes and the overlay, (7) on the Bayou Lafourche Bridge, most overlay problems occurred in the outside traffic lane, (8) a slag plant mix seal surfacing, mistakenly placed on Spans 7, 8 and 9 in the inside traffic lane, appeared satisfactory in evaluations and (9) installation procedures, construction traffic and the material itself caused varying degrees of problems along with the changing conditions since the primary conclusion reached herein related the relative ineffectiveness of waterproofing of the various membrane systems evaluated, as shown by the electrical resistivity, a detailed description or rating for each system will not be attempted.

RECOMMENDATIONS

The primary recommendation of this report is that the State of Louisiana do not accept the concrete bridge deck membrane systems evaluated herein for use as waterproofing materials on concrete decks in Louisiana.

Since the need to protect and waterproof concrete bridge decks, primarily from the effects of de-icing salts on concrete and reinforcing steel, is still with us, research in other methods of protection should continue.

If new membrane systems appear promising or successful, further experimental projects should be considered. However, further evaluations of any waterproofing systems should be monitored closely, especially with regard to installation procedures, construction traffic and testing procedures. No membranes should be put down, until all problems related to installation are solved. Materials in the laboratory should not be tested at a temperature lower than $0^{o}F$.

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5. H. A. Lindberg, FHWA Notice, National Experimental and Evaluation Program, NEEP No. 12, Electrical Resistivity Testing of Membranes, November, 1974.

6. D. B. Mellott, Asbestos-Asphalt Impermeable Membranes for Concrete Bridge Decks. Research Project No. 71-2, Pennsylvania Department of Transportation, Bureau of Materials, Testing and Research, September, 1972.

APPENDIX

Figure 19
Joint between Spans 5-6
1-Year Evaluation

Figure 20
Joints between Spans 7-8
1-Year Evaluation

Figure 21
Patches on Span 8
(System 4)

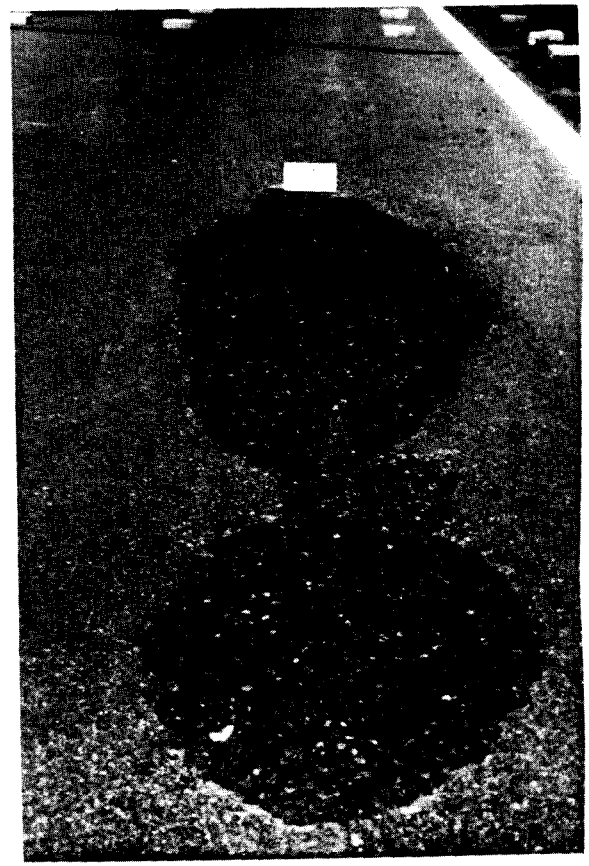

Figure 22
Patches on Span 8
(System 4)

Figure 23
Overlay Shoving on Exit Ramp
Span 10 (System 1)

Figure 24
Overlay Patches Shoving on
Span 7 (System 4)

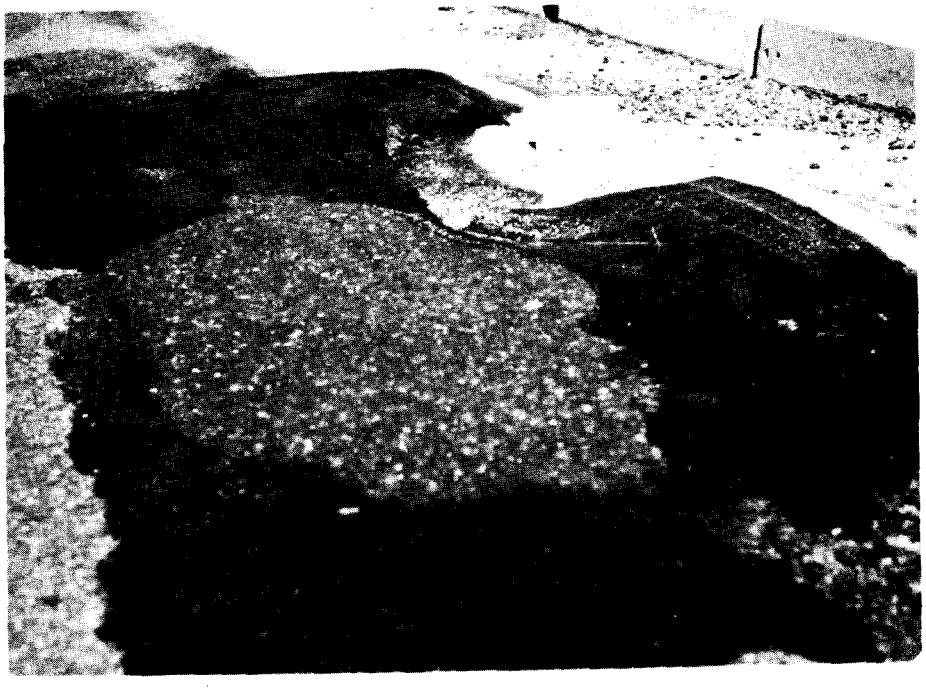

Figure 25
Overlay Patches Shoving
on Span 8 (System 4)

Figure 26
Overlay Patches Shoving - Span 8 (System 4)

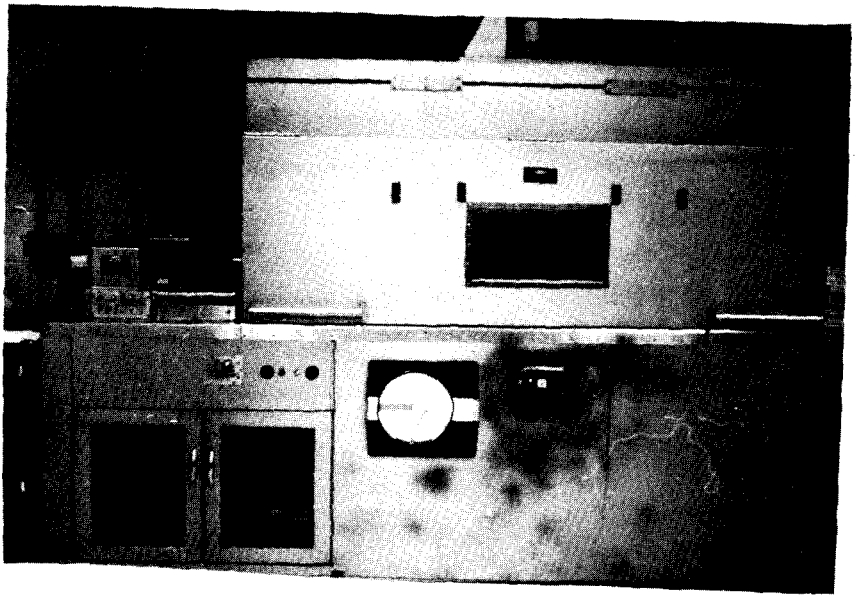

Figure 27
Bostic Test Chamber

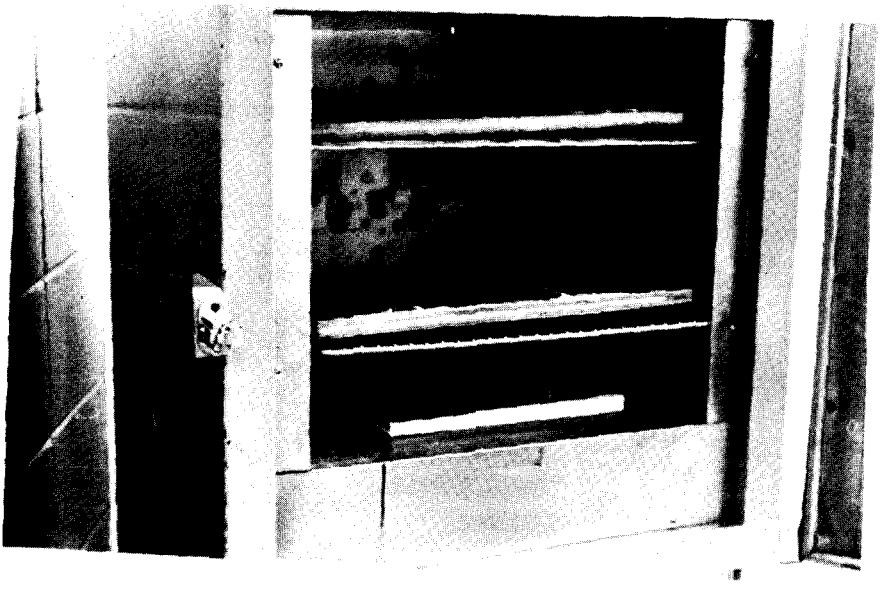

Figure 28
Oven with Specimens for
Heat Age Test

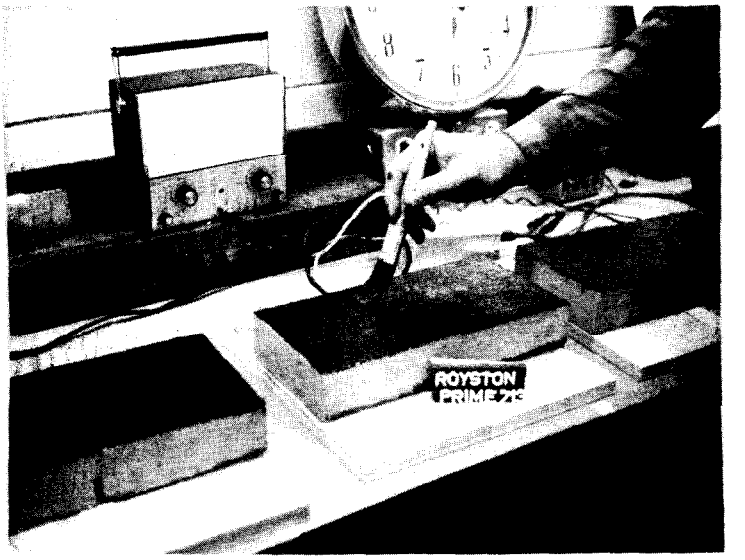

Figure 29
Application of Material on Test Block

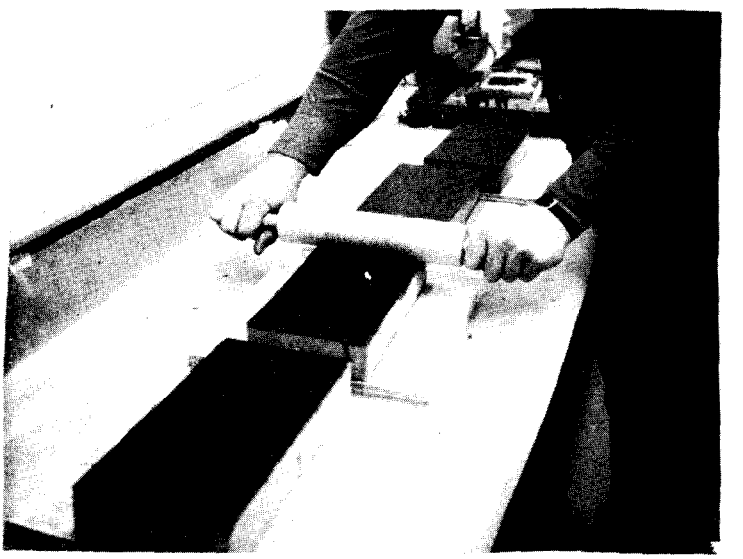

Figure 30
Rolling of Material on Test Block

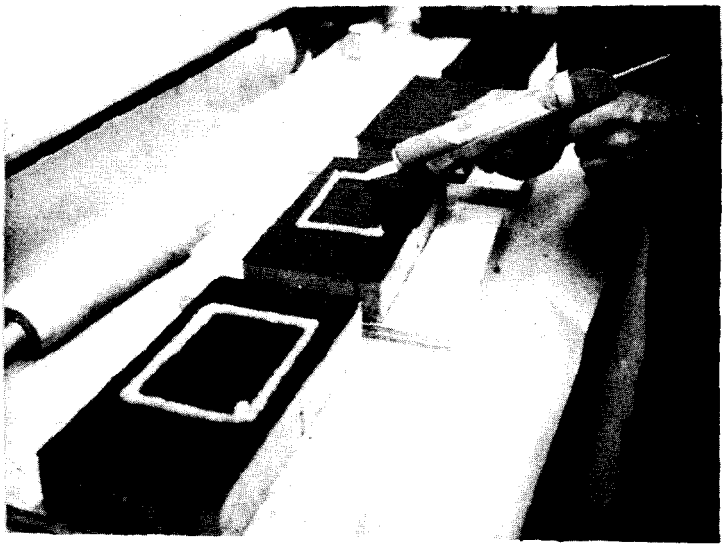

Figure 31
Application of Silicone Dam
over Material on Test Block

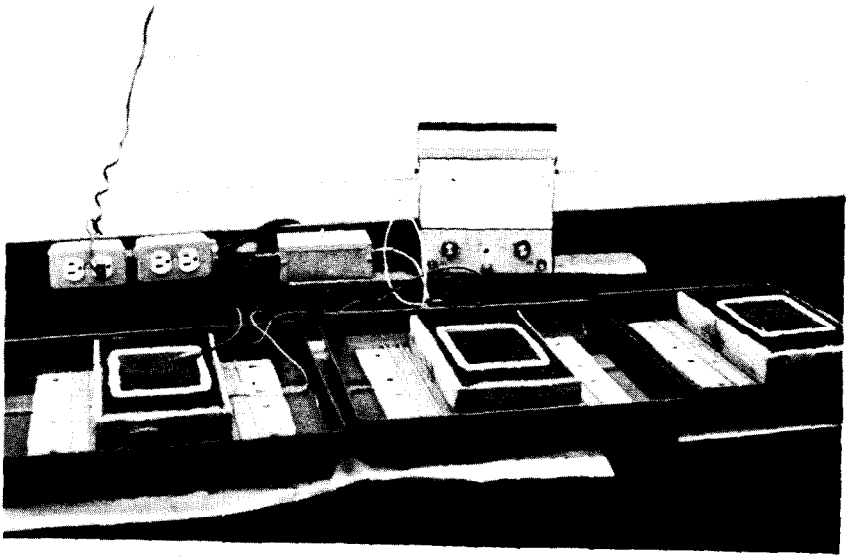

Figure 32
Resistivity Test Setup

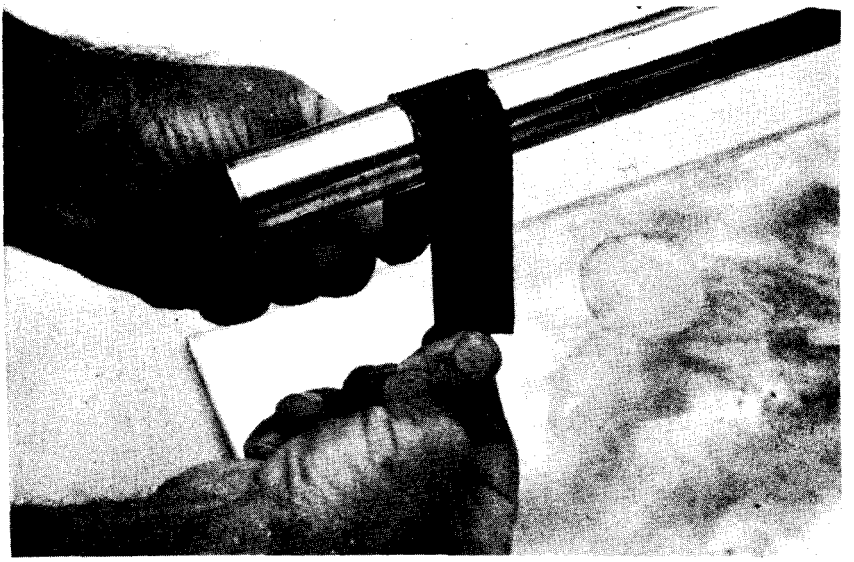

Figure 33
Heat Aged Bend Test

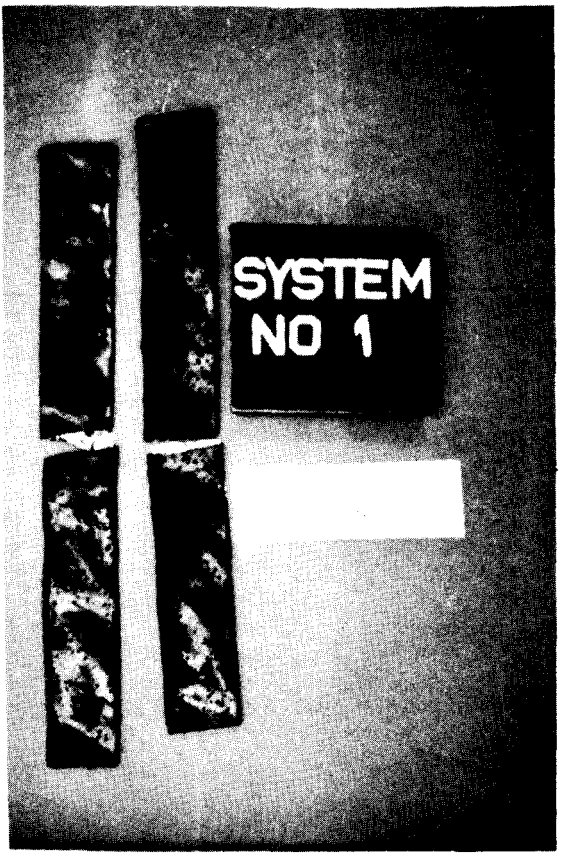

Figure 34
Results: Heat-Aged Bend Test
@ 0°F., System No. 1

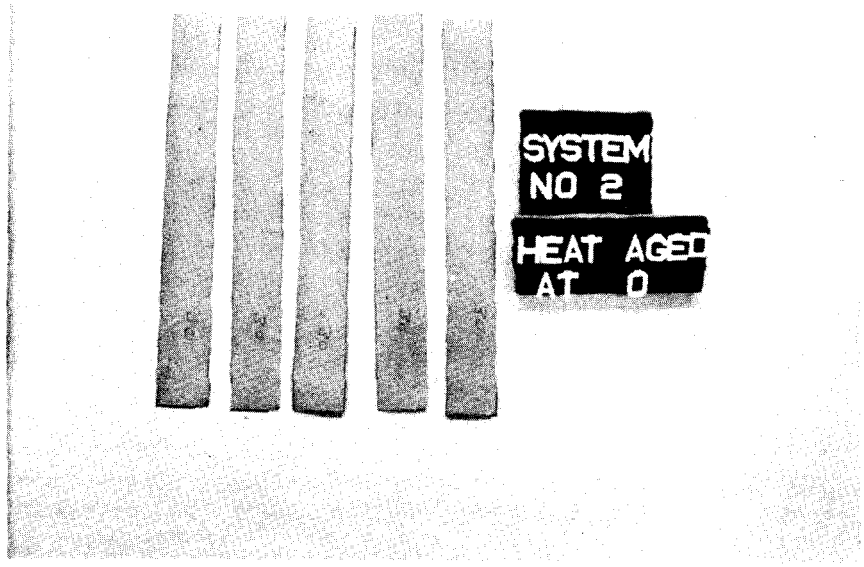

Figure 35
Results: Heat Aged @ 0°F.,
System No. 2

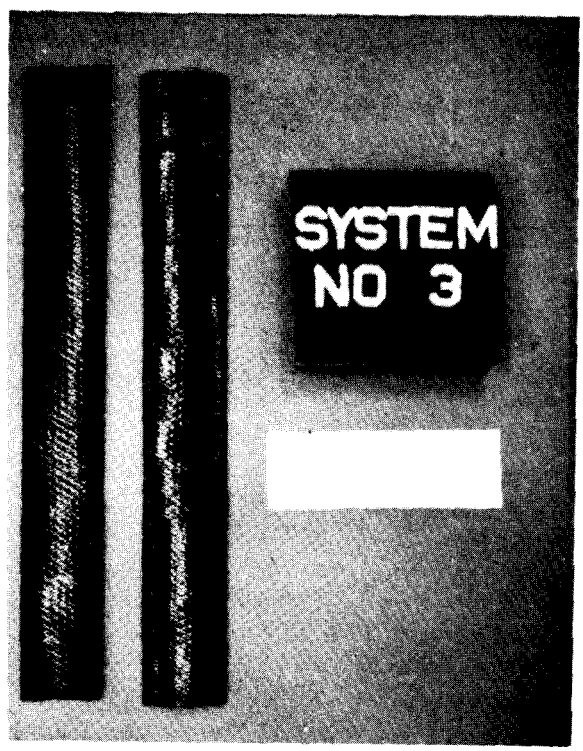

Figure 36
Results: Heat-Aged Bend Test @ 0°F.,
System No. 3

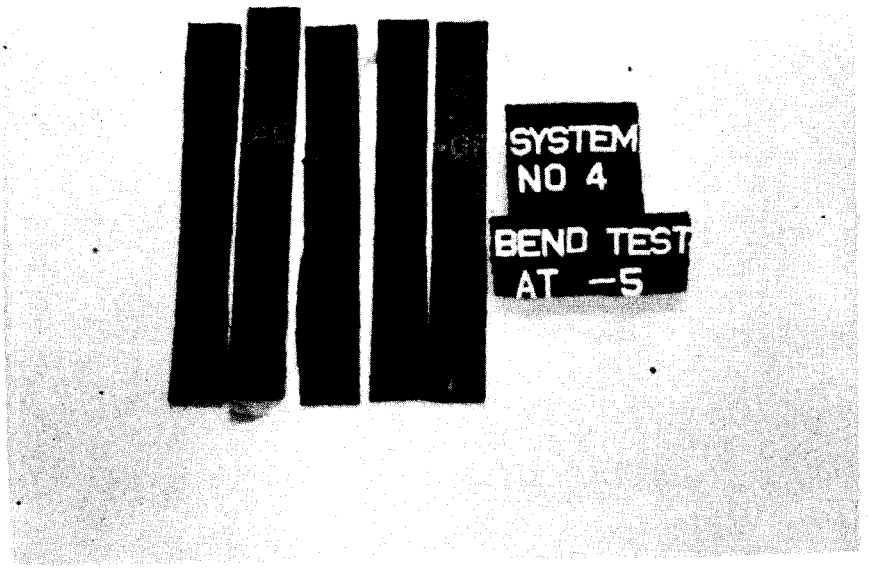

Figure 37
Results: Bend Test @ -5°F.,
System No. 4

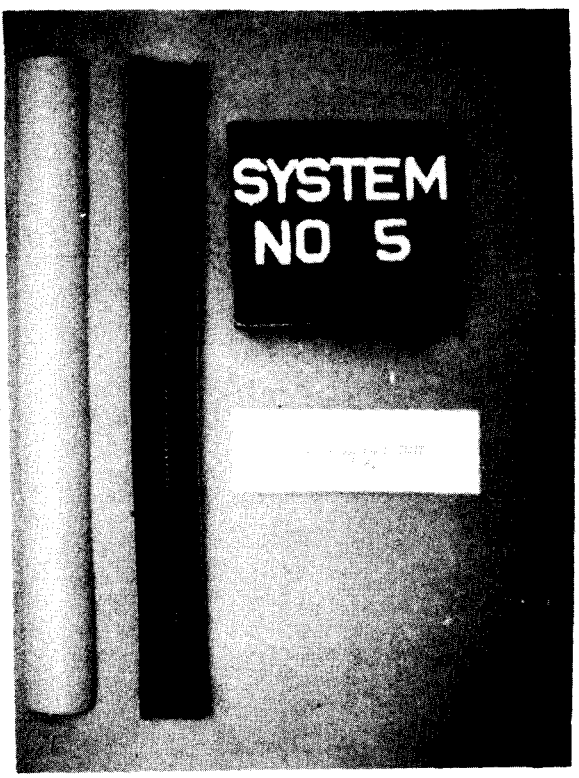

Figure 38
Results: Heat-Aged Bend Test @ 0°F.,
System No. 5

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SCOPE OF WORK: This project consists of rehabilitating existing bridge decks which have deteriorated due to climatic conditions and the use of de-icing salts. This work includes removing and replacing unsound concrete, installing new expansion joint seals, placing protective membranes and placing granite asphaltic concrete.

LOCATION OF PROJECT: The bridge decks involved in this rehabilitation work are at the following locations:

State Project No. 451-06-46
Federal Aid Project No. I-20-3(54)116
Bridge No. 4510617947
Ouachita Parish
Located on Spans S2-10 and S2-11 of the Second Street Off Ramp (Ramp S-2) in Monroe.

State Project No. 451-07-19
Federal Aid Project No. I-20-3(55)127
Bridge No. 4510700271
Richland Parish
Located on the Westbound Route I-20 Bayou Lafourche Bridge approximately 5 miles east of Monroe.

MAINTENANCE OF TRAFFIC: Westbound Route I-20 traffic will be maintained at all times by performing the work on only one lane at a time on the Bayou Lafourche Bridge. The Second Street exit (Ramp S-2) will be closed to all traffic during the deck rehabilitation work.

PLANS AND SPECIFICATIONS: All work on this project will be performed in accordance with the plan details and the Louisiana Department of Highways Standard Specifications, dated October 1971, with amendments as specified hereinafter.

BARRICADE WARNING LIGHTS: Subsection 915.16 of the Standard Specifications is amended as follows. Headings (a), (b), (c) and (d) are deleted and the following is substituted therefor. Types A, B and C barricade warning lights shall be in accordance with Section 6D-5 of the Louisiana Manual on Uniform Traffic Control Devices. All mountings on which the warning lights are attached, including the portable supports specifically for these warning lights, shall be reflectorized by the use of encapsulated lens reflective sheeting as specified on Standard Plan RS 24.

WELDING: Section 916 of the Standard Specifications and the LDH Welding Procedures Manual are amended as follows.

Subsection 916.02 is revised to state that all notices and reports that are required to be submitted shall be sent to the Department's Construction Section.

The LDH Welding Procedures Manual is amended as follows.

Section 4, Technique:

(1) Add the following paragraph 401(d) immediately below the first sentence of paragraph 401(c).

(d) For unpainted applications of A 588 steel where welds with atmospheric corrosion resistance but not exact color match are acceptable to the engineer, filler metals of Table 3a may be used as follows.

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(2) Table 4 of paragraph 402 is revised as follows.

For A 36 steel to 3/4" thickness, inclusive, when welded with other than low-hydrogen electrodes, the minimum preheat and interpass temperature shall be 150° F.

For all steels to 3/4" thickness, inclusive, when welded with low-hydrogen electrodes, or with submerged arc, gas metal-arc or flux cored arc welding, the minimum preheat and interpass temperature shall be 50° F.

Section 5, Electroslag and Electrogas Welding: The use of electroslag welding will not be permitted.

SIGNS AND MARKERS: Section 917 of the Standard Specifications is amended as follows.

Subsection 917.03(a)(2)a, Adhesive: The second sentence of the first paragraph of this heading is deleted and the following substituted therefor. The encapsulated lens type reflective sheeting shall include a precoated pressure sensitive adhesive or a tack-free, heat activated adhesive.

Subsection 917.03(a)(2)b, Photometric: Table II is amended in include the following values for red, orange and blue encapsulated lens reflective sheeting.

	Red		Orange		Blue	
Div. Angle	.2	.5	.2	.5	.2	.5
Inc. Angle						
-4	35.0	13.0	60.0	20.0	20.0	7.5
40	17.0	7.5	25.0	13.0	9.0	4.2

Subsection 917.03(a)(2)f, General Characteristics and Packaging: The last three paragraphs of this heading are deleted and the following substituted therefor. The material shall be packaged in such manner as to assure arrival in an undamaged condition and shall not be allowed to become wet during storage or shipment.

Subsection 917.07(e), Applying Sign Face and Legend Sheeting: This subsection is amended as follows. Reflective sheeting shall be applied to the metal panels in such a manner that there are no horizontal splices.

Subsection 917.07(f)(2), Hazard Markers, is deleted and the following substituted therefor. Hazard markers shall be silver reflectorized material in accordance with Subsection 917.03 and low gloss black nonreflectorized material in accordance with Subsection 917.03 or 917.06, mounted on aluminum sheeting of 0.08" minimum thickness or galvanized steel sheeting of 12 gage minimum thickness.

STEEL REINFORCED ELASTOMERIC JOINT SEAL: The Transflex 200A steel reinforced elastomeric joint seals shall be installed in accordance with the manufacturer's recommendations.

PREFORMED ELASTOMERIC JOINT SEAL: Preformed elastomeric joint seals used with epoxy concrete expansion dams shall conform to Section 905 of the Standard Specifications and the manufacturer's specifications.

Immediately prior to placing the seal the joint shall be cleaned with high pressure air jets to remove all residue and foreign matter. Joint surfaces shall be dry at the time the seal is placed.

The seal shall consist of a multi-channel, nonporous, homogeneous material furnished in a finished extruded form. The manufacturer shall designate the minimum uncompressed width of each size seal to be furnished. Seals that have an uncompressed width, measured at any point in the height of the seal, less than that designated by

the manufacturer and seals delivered to the job site that have dimensional or shape tolerances of such magnitude that the seal will not function as required shall not be used. The seals shall be furnished full length for each joint with not more than one shop splice in any 60-foot length seal. Field splices will not be permitted.

The adhesive used to splice the seal shall be an effective bonding agent and resistant to water and ozone. All abutting surfaces of shop splices shall be bonded together with adhesive, with no visible offset of the exterior surfaces. There shall be no visible evidence of bond failure after the seals have been installed in the joints.

Each cell at the open ends of the elastomeric joint seals shall be filled to a depth of 3" with a one-component extrudable polyurethane joint sealer conforming to Subsection 905.01(b). The same polyurethane joint sealer shall be used to seal the remaining armored joint at the face of the curb.

Immediately prior to installation, a lubricant-adhesive conforming to Subsection 905.02(b)(2), shall be liberally applied to the sides of the seal and to all vertical surfaces of the groove which will be in contact with the seal. Just prior to applying the lubricant-adhesive the contact surfaces of the seal and the top surface, 1/2" from either side, shall be cleaned with normal butyl acetate, using clean rags or mops.

The seals shall be positioned according to the dimensions from the top of deck shown on the plans, and the top edges of the seal shall be in a plane normal to the sides of the groove. The installation equipment shall not twist, distort, or elongate the seal longitudinally or cause other damage to the seals, nor shall it cause structural damage to the concrete.

EPOXY RESIN ADHESIVE: Epoxy resin adhesive and epoxy concrete shall conform to the following requirements and shall be applied in accordance with the manufacturer's recommendations.

Unsound concrete shall be removed and existing reinforcing steel that has been exposed shall be restored to its original position, and reinforcing steel that has been damaged beyond repair shall be replaced in accordance with Section 806 of the Standard Specifications.

Cleaning of contact surfaces shall be accomplished by abrasive blastcleaning the concrete and steel as necessary to remove all rust, paint, grease or other foreign materials. Surfaces shall be recleaned by sweeping and pressure jetting, or by other approved means, as necessary to remove debris which has accumulated during or after abrasive blastcleaning.

The expansion dams shall be built as shown in the plans prior to placement of the membrane and asphaltic concrete.

Where dowels are to be bonded in holes drilled into existing concrete, the holes shall be drilled by methods that will not shatter or damage the concrete adjacent to the holes. The drilled holes shall be clean and dry at the time of placing bonding material and steel dowels. Bonding material and steel dowel shall completely fill the drilled hole. The bonding material shall be an epoxy adhesive conforming to AASHO Designation: M-235-731, Class II. After bonding, dowels shall remain undisturbed until the epoxy adhesive has reached a strength sufficient to support the dowel. Dowels that are improperly bonded shall be removed. The holes shall be cleaned or new holes drilled and the dowels replaced and securely bonded to the concrete

Epoxy concrete shall consist of a mixture of epoxy resin adhesive and aggregate. The epoxy resin adhesive shall conform to the requirements of AASHO Designation: M-235-731, Class II. Aggregate shall conform to section 903 of the Standard Specifications. The aggregate when mixed with the adhesive shall be clean and surface dry.

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The aggregate size and proportions and the exact proportions of adhesive to aggregate shall be as ordered by the engineer. The aggregate size and proportions will be between the limits of coarse aggregate for epoxy concrete. Aggregate gradation shall conform to Grade "A" aggregate in Subsection 903.03. The proportion of coarse aggregate in the mix shall be 30% to 40% of the total aggregate, by dry volume.

The minimum temperature of the epoxy concrete after mixing shall be 50° F, except that when the ambient temperature is below 50° F the minimum temperature of the epoxy concrete shall be 65° F. The mix proportions of the opoxy concrete shall be one part of adhesive to approximately four parts of aggregate by dry volume.

The aggregate shall be stored and proportioned so as to give a uniform combined material. The aggregate and the epoxy binder shall be mixed in equipment and by methods that result in a homogeneous mixture.

The areas to be covered shall be surface dry and the surface temperature shall be at least 50° F when the epoxy concrete or epoxy adhesive is applied.

The areas to be filled or covered, including reinforcement, shall be coated with the same adhesive used in producing epoxy concrete applied at the approximate rate of one gallon for each 25 square feet of area. The adhesive shall be worked onto the surface with stiff brushes, or approved equal methods. The filling or covering material shall be applied before the adhesive begins to set.

Immediately after placing, the epoxy concrete shall be thoroughly tamped into place with sufficient energy to minimize air voids and bring an excess of binder to the surface. Surfaces shall be struck off to the required grade.

Whenever the top surface of epoxy concrete is to be covered with asphaltic concrete, or will be the exposed surface of a roadway or sidewalk, a nonskid surface finish shall be provided by sprinkling sharp, coarse sand onto the surface of the epoxy concrete. The sand shall conform to the quality and dryness requirements specified herein for aggregate.

When forms are required to produce the lines and grades shown on the plans, the forms shall be coated with paraffin, silicone grease, or polyethylene sheet.

When forms are used for dams, the forms shall be constructed such that the movement of any expansion joint will not be translated into the forms supporting the fresh epoxy concrete or epoxy mortar. Solid bracing or strutting for forms shall not be used across any expansion joints.

When required for filling scaled areas, the following 3-step broadcast system shall be used.

(1) Primer - Colma-Dur LV, a low-viscosity, two-component, 100%-solids epoxy-resin system. It acts as both a primer and a seal coat to reinforce the substrate.

(2) Binder - Colma-Dur, a two-component, 100%-solids epoxy-resin system. It is the binder for the broadcast aggregate and it also provids additional sealing and wear resistance.

(3) Aggregate - Colma Quartzite Aggregate adds skid-resistance and reinforces the entire system.

Coverage rates are as follows:

Colma-DurLV	160 to 190 sq. ft. per gal.
Colma-Dur	30 sq. ft. per gal.
Colma Quartzite Aggregate	2 lb. per sq. ft.

All bonding surfaces must be clean, dry and sound. Remove laitance, surface dirt, curing compounds, grease, impregnations, waxes, and soft or deteriorated concrete by sandblasting or mechanical abrasion.

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Spalled and deteriorated areas shall be repaired with Colma-Dur mortar. Prime clean, sound area with neat Colma-Dur. Prepare patching mortar with one part by volume of mixed Colma-Dur and three parts of Colma Quartzite Aggregate.

Before mixing the broadcast system materials, condition the Colma-Dur LV, Colma-Dur, and Colma Quartzite Aggregate to approximately 75° F for ease of mixing and handling. As temperatures decrease, workability of the epoxy decreases.

Premix Component 'B' of Colma-Dur for 1 minute with Colma Mixing Paddle attached to low-speed (400 - 600 rmp) electric drill.

Premixing is not required for Colma-Dur LV Components. Mix proportions:

(a) Colma-Dur LV - pour 2 parts by volume of 'A' and 1 part 'B' into clean container.

(b) Colma-Dur - pour 1 part of 'A' and 1 part of 'B' into a second clean container.

Mix for 3 minutes to achieve uniform blend and color. Move drill continuously to mix components thoroughly. Keep paddle below surface of material to avoid whipping air into mix. Mix only that quantity which can be applied within 15 minutes.

1. Prime area to be surfaced with 1 coat of Colma-Dur LV using long-nap roller or rubber squeegee at a rate of 160 to 190 sq. ft. per gallon.
2. Shortly after priming, but while Colma-Dur LV is still tacky, pour out Colma-Dur and spread with notched (3/16") rubber squeegee at rate of 30 sq. ft. per gallon.
3. While Colma-Dur is still liquid, drop Colma Quartzite Aggregate vertically into epoxy at uniform rate of 2 lb. per sq. ft. Make sure entire epoxy surface is thoroughly covered.
4. Protect finished surface against vehicular and pedestrian traffic during normal air-curing period (5 hrs. @ 75° F).
5. After epoxy has hardened so that is cannot be dented with a screwdriver or other blunt instrument, remove excess sand.

ASPHALTIC CONCRETE: Sections 501, 502 and 903 of the Standard Specifications are amended as follows.

The asphaltic concrete mixture shall be placed in such manner as to avoid displacement of the waterproofing membranes.

Subsection 501.09 is amended to require the use of rubber-tired pavers equipped with a 30-foot traveling stringline.

Subsection 501.10 is deleted and the following substituted therefor. Rolling equipment shall consist of any roller or combination of rollers needed to compact the mix to the required density and surface smoothness. Rollers must be capable of maintaining the pace of the bituminous paving operation, and must be capable of reversing without backlash.

Steel wheel rollers shall be equipped with adjustable scrapers to keep the rollers clean and with efficient means of keeping the wheels wet to prevent the mixture from sticking to the rollers. Rollers shall also be free of flat areas, openings or projections which will mar the surface of the pavement.

Rollers that employ the use of pneumatic tires shall be equipped with coca mats or suitable scrapers to prevent pickup. Suitable devices will also be provided to keep the mats damp.

Subsection 502.01 is amended to require a Type 3 wearing course mixture composed of crushed granite graded from coarse to fine. Mineral filler is not required but shall be added as needed to meet the physical requirements. AC 40 grade asphalt sahll be used.

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Subsection 502.09 is amended to require the use of nuclear density devices in lieu of coring as specified in LDH Designation: TR 304.

Subsection 903.07(c) is deleted and the following substituted therefor. The aggregate shall consist of crushed granite from an approved source meeting the requirements given in Table VII for Type 3 wearing course with the exception of the filler content which shall be used as needed to meet the physical requirements.

Crushed granit shall be obtained from clean, tough, sound, durable rock. The particles shall be reasonably free from dust, vegetable matter, or other deleterious matter, and shall not show an abrasion loss of more than 40% by the Los Angeles abrasion test. It shall show a soundness loss of not more than 15% by weight when subjected to 5 cycles of the magnesium sulfate soundness test. The crushed granite will show a solubility loss of not over 5% by weight when tested in accordance with LDH Designation: TR 115, or an ignition loss of not over 5% by weight when tested in accordance with LDH Designation: TR 114. However, the combined loss by these two tests shall not exceed 8% by weight.

Table VII is amended as follows. The gradation of the aggregate will be Type 3 wearing course meeting the requirements given therein except that the material will be 100 percent passing 1/2" sieve.

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SPECIFICATIONS FOR BRIDGE DECK MEMBRANES

1.0 This is an experimental project and only those waterproofing membranes as specified on the plans shall be used.

2.0 MATERIAL CERTIFICATION

2.1 The manufacturer shall furnish a certification in triplicate to the Department certifying that the materials supplied conforms to all requirements specified and stating that the material is formulated the same as the material tested for manufacturer and brand name approval. The certification shall include or have attached specific test results for all specified properties on Mixed Material for each lot supplied.

2.2 The Department reserves the right to sample and test any or all material supplied.

3.0 SURFACE PREPARATION

3.1 The surface of the deck, the sides of the curbs, for a height of at least one inch above the proposed asphaltic concrete overlay; and the interior of curb scruppers shall be thoroughly cleaned by the use of air jets, sandblasting, mechanical sweeper, hand brooms, or other approved methods, until the deck surface, interiors of curb scruppers, and side of the curbs are free of all sand, clay dust, salt deposits, oil or grease deposits, and all loose or forein matter. All epoxy seal coats which do not have at least a coarse sand texture shall be sand blasted or power sanded to provide a roughened surface. All dust and dirt shall be blown off with air jets immediately preceding application of the primer. The surface of the deck shall be visibly dry prior to and during application.

4.0 APPLICATION

4.1 Application shall be in strict accordance with the manufacturer's instructions. The manufacturer shall furnish the Department a copy of the manufacturer's printed instructions for application and construction procedures recommended. A Technical Representative of the manufacturer shall be present on the job during the application of the entire membrane waterproofing system. The Technical Representative shall supply detailed instructions supplementing those specified herein for use in applying the material. He shall inspect the concrete deck immediately prior to application of the membrane.

4.2 Membrane systems are to be protected in accordance with the manufacturer's recommendations.

4.3 Neither the primer nor the membrane shall be applied with the air temperature or deck temperature is below 50° F. The deck shall be surface-dry at the time of application of the primer.

4.4 No vehicle other than the asphalt overlay equipment shall be permitted on the membrane prior to the asphaltic overlay. Overlay equipment wheels and tires shall be clean and free from stones or other material which could penetrate the membrane.

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SPECIFICATIONS FOR BRIDGE DECK MEMBRANES

4.5 Extreme care should be taken when compacting the asphaltic concrete mixtures to prevent sudden stops and starts by the rollers.

4.6 When it is necessary to maintain traffic during application, the membrane shall be applied to one half of the bridge open to traffic. After the membrane has been applied to the entire length of the structure to the width specified, the asphaltic concrete overlay shall be applied to one half of the bridge width leaving the one foot width of membrane exposed for overlap in completing the remaining portion of the bridge. After the asphaltic concrete overlay is in place, traffic can be routed over the completed half of the bridge and work commenced on the remainder.

5.0 SYSTEM 1 MATERIALS

5.1 The materials used in this waterproofing system shall consist of a hot poured elastomeric membrane. The system shall be the Superseal 4000 Bridge Waterproofing Membrane System, a product of Superior Products Company.

5.1.1 The membrane shall be a hot poured liquid which is poured or pumped into a double boiler, oil bath, melter-applicator type kettle approved by the manufacturer and heated to 375° F and applied to the cleaned concrete surface by spraying with a special type nozzle, or poured onto the surface and worked into the surface with a silicone rubber squeeze to a 90 mil thickness. The membrane shall have the following properties.

Penetration	ASTM D1190	1.20 cm max., after 48 hours room temperature 77° F
Flow	ASTM D1190	No flow, 72 hours, at 158° F
Bond	ASTM D1190	1/4" separation, 3 cycles, 0° F
Resilience		50% min., after 48 hours room temperature 77° F
Elongation		500% 1/2" per min., 77° F
Pliability		No cracks when slowly bent at 10° F over a one inch mandrel

5.2 Certification and Sampling - Certification and sampling shall be in accordance with paragraph 2.0 of these specifications.

5.3 Surface Preparation - Surface Preparation shall be in accordance with paragraph 3.0 of these specifications.

5.4 Application - Application shall be in accordance with paragraph 4.0 of these specifications.

6.0 SYSTEM 2 MATERIALS

6.1 The materials used in this waterproofing shall consist of a cold-applied prefabricated reinforced vinyl-elastomer membrane over a adhesive primer. Prior to overlaying a topping shall be placed onto the membrane. This system shall be manufactured by the Hydro-Ban Corporation and consist of the following: the Hydro-Ban Adhesive/Primer HB110, the Hydro-Ban Elastomeric Membrane RVM-30, and the Hydro-Ban Topping HB525.

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SPECIFICATIONS FOR BRIDGE DECK MEMBRANES

6.1.1 The membrane shall be prefabricated membrane, Hydro-Ban RVN-30, consisting of a layer of nylon scrim bonded between layers of polyvinyl chloride sheets and having a layer of elastomer on the bottom. The membrane shall have the following properties:

PHYSICAL PROPERTIES

Total Thickness:	
(Minimum)	.030" (ASTM-D-1000)
Tensile Strength	2500 psi (ASTM-D-882)
Bonded Elongation	330% (ASTM-D-638)
Tear Resistance (1" sq.)	
Crosswise	825 lbs. (ASTM-D-1004)
Lengthwise	800 lbs. (ASTM-D-1004)
Operating Temperature	-20° F to 160° F
Moisture Absorption	
Moisture Vapor Transmission	
Moisture Absorption	0.08% (ASTM-D-570)
Grams/ 100 sq. in./24 hrs..	0.02 (ASTM-D-127)
Abrasion Resistance	
Loss of gauge	0.011" (MIL-L-7798A)

CHEMICAL PROPERTIES

(These Method ASTM-D-543-52T, where applicable)

Resistance to	
Salt Water	Excellent
Alkalines	Excellent
Alcohols (water soluble)...	Good
Acids (organic and inorganic, except oxidizing agents)	Good to Excellent
Ambient Temperatures	Excellent
Weathering	Excellent
Hydrocarbons, Resistance to	
Aliphatic	Excellent
Aromatic	Fair to Good
Bacteria	Excellent
Fungus	Excellent
Animal & Plant Acids	Excellent
Bond strength to dry steel surfaces:	
Minimum: 10 lbs/in of width	
Bond strength to concrete:	
180 degree peel: 40 lbs/in of width	
Bond strength to plywood:	
180 degree peel: 20 lbs/in of width (delaminates plywood)	

6.2 Certification and Sampling - Certification and sampling shall be in accordance with paragraph 2.0 of these specifications.

6.3 Surface Preparation - Surface preparation shall be in accordance with paragraph 3.0 of these specifications.

6.4 Application - Application shall be in accordance with paragraph 4.0 of these specifications.

7.0 SYSTEM 3 MATERIALS

7.1 The materials used in this waterproofing system shall consist of cold applied prefabricated reinforced coal tar barrier membrane over a coal tar synthetic resin primer. The system shall be the Protecto Wrap M-400 Bridge Membrane Waterproofing System.

7.1.1 Primer shall be an approved solvent release modified coal tar synthetic resin, Protecto Wrap No. 80 Primer and shall have the following properties:

Property	Test Method	Results
Viscosity		400 to 600 cps-Brookfield, Viscosity Meter Model RVF at 77° F, Spindle No. 1-2 RPM.
Specific Gravity	ASTM D70-72	1.000 to 1.110
Non Volatile Content	ASTM D2697-72	42.0 to 45.0% by volume
Flash Point	ASTM D1310-72 (Tag Open Cup)	25° F, Minimum

7.1.2 Membrane shall be an approved prefabricated material composed of premium grade coal tar modified with synethetic resins and reinforced with synthetic non-woven fabric, Protecto Wrap-M-400 Bridge Membrane and shall have the following properties.

Property	Test Method	Results
Tensile Strength and Elongation	ASTM D882-73 1" wide strip-speed of pull 2" per minute	Minimum avg. of 3 samples Tensile longitudinal 0° F ..... 1600 psi 40° F ..... 1200 psi 120° F ..... 500 psi Tensile Transverse 0° F ..... 1600 psi 40° F ..... 900 psi 120° F ..... 450 psi Elongation longitudinal 0° F, 40° F & 120° F ..... 60% Elongation transverse 0° F, 40° F & 120° F 70%
Slump	TT-C-598-B paragraph 4.37 modified for Mastic on Tape	0" at 158° F
Softening Point	ASTM D-36-70	240° F Minimum
Flexibility	Federal Test Method Standard 141, method 6221	Shall pass 1" mandrel test at 10° F
Thickness		70± mils not including separator sheet

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SPECIFICATIONS FOR BRIDGE DECK MEMBRANES

7.1.3 Mastic shall be a synethetic resin and fiber modified coal tar solution coating Protecto Wrap - CA 1200 and shall have the following properties:

Property	Test Method	Results
Viscosity		200,000 to 500,000 cps - Brookfield Viscosity meter model RVF at 77°F, Spindle No. 6-2 RPM
Specific Gravity	ASTM D-70-72	1.150 to 1.300
Non Volatile Content	ASTM D2697-72	53.0 to 57.0% by volume
Flash Point	ASTM D56-73	30°F, minimum

7.1.4 Each roll of sheet membrane shall be clearly marked with the manufacturer's name and a lot or batch number.

7.2 Certification and Sampling - Certification and sampling shall be in accordance with paragraph 2.0 of these specifications.

7.3 Surface Preparation - Surface preparation shall be in accordance with paragraph 3.0 of these specifications.

7.4 Application - Application shall be in accordance with paragraph 4.0 of these specifications.

8.0 SYSTEM 4 MATERIALS

8.1 Materials - The materials used in this waterproofing system shall consist of: a cold-applied self-adhering membrane incorporating a woven polypropylene mesh embedded between a layer of self-adhesive rubberized asphalt and a non-tacky bituminous compound; a primer, and a mastic. The system shall be the Heavy Duty Bituthene Waterproofing Membrane system, a product of Construction Products Division, W. R. Grace and Company.

8.1.1 Membrane shall be a prefabricated membrane, Heavy Duty Bituthene, consisting of a woven polypropylene mesh embedded between a layer of self-adhesive rubberized asphalt and a non-tacky bituminous compound and shall have the following properties:

Property	Test Method	Results
Color	Visual	Black
Tensile Strength, psi	ASTM D882-73 Method A	300 Minimum
Elongation at break percent	ASTM D882-73 Method A	150 Minimum
Thickness, mils		65 Minimum
Adhesion in peel, lbs/in.width after 7 days water immersion at 75 F.	Fed. TT-S-00230 Modified	5.0 Minimum
Pliability	ASTM D146-72	No cracks when bent 180°F around 1 inch mandrel at -5°F

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8.1.2 Primer shall be a neoprene solution with the following properties:

Property	Test Method	Specific Value
Weight per Gallon, lbs.	ASTM D1475-60 (1968)	7.5 ± 0.5
Percent Solids	ASTM D1644-59 (1970)	12.0 - 14.0
Flash Point	ASTM D1310-72 (Tag Open Cup)	80°F Minimum

8.1.3 Mastic shall be a rubberized asphalt compound with plasticizers and fil.

8.1.4 Each roll of sheet membrane shall be clearly marked with the manufacturer's name and a lot or batch number.

8.2 Certification and Sampling - Certification and sampling shall be in accordance with paragraph 2.0 of these specifications.

8.3 Surface Preparation - Surface preparation shall be in accordance with paragraph 3.0 of these specifications.

8.4 Application - Application shall be in accordance with paragraph 4.0 of these specifications.

9.0 SYSTEM 5 MATERIALS

9.1 The materials used in this waterproofing shall consist of a cold-applied prefabricated reinforced vinyl-elastomer membrane over an adhesive primer. Prior to overlaying a topping shall be placed onto the membrane. This system shall be manufactured by the Hydro-Ban Corporation and consist of the following: the Hydro-Ban Adhesive/Primer HB110, the Hydro-Ban Elastomeric Membrane RVN-45, and the Hydro-Ban Topping HB525.

9.1.1 The membrane shall be prefabricated membrane, Hydro-Ban RVN-45, consisting of a layer of nylon scrim bonded between layers of polyvin l chloride sheets and having a layer of elastomer on the bottom. The membrane shall have the following properties:

PHYSICAL PROPERTIES

Total Thickness:
(Minimum) ..... .045" (ASTM-D-1000)
Tensile Strength ..... 2500 psi (ASTM-D-882)
Bonded Elongation 330% (ASTM-D-638)
Tear Resistance (1" sq.)
Crosswise ..... 825 lbs. (ASTM-D-1004)
Lengthwise ..... 800 lbs. (ASTM-D-1004)
Operating Temperature ..... -20°F to 160°F
Moisture Vapor Transmission
Moisture Absorption 0.08% (ASTM-D-570)
Grams/100 sq.in./24 hrs. ... 0.02 (ASTM-D-127)
Abrasion Resistance
Loss of gauge ..... 0.011" (MIL-L-7798A)

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CHEMICAL PROPERTIES

(Test Method ASTM-D-543-52T, where applicable)
Resistance to
- Salt Water ..... Excellent
- Alkalies ..... Excellent
- Alcohols (water soluble) ..... Good
- Acids (organic and inorganic, except oxidizing agents) ..... Good to Excellent
- Ambient Temperatures ..... Excellent
- Weathering ..... Excellent

Hydrocarbons, Resistance to
- Aliphatic ..... Excellent
- Aromatic ..... Fair to Good
- Bacteria ..... Excellent
- Fungus ..... Excellent
- Animal & Plant Acids ..... Excellent

Bond strength to dry steel surfaces:
Minimum: 10 lbs/in of width
Bond strength to concrete:
180 degree peel: 40 lbs/in of width
Bond strength to plywood:
180 degree peel: 20 lbs/in of width (delaminates plywood)

9.2 Certification and Sampling - Certification and sampling shall be in accordance with paragraph 2.0 of these specifications.

9.3 Surface Preparation - Surface preparation shall be in accordance with paragraph 3.0 of these specifications.

9.4 Application - Application shall be in accordance with paragraph 4.0 of these specifications.

10.0 SYSTEM 6 MATERIALS

10.1 The materials used in this waterproofing shall consist of a cold applied prefabricated laminate consisting of an impregnated fiberglass mesh sandwiched between layers of a bituminous mastic with a top surface of polyester film placed over an adhesive primer. The system shall be the Royston Bridge Membrane No. 10 placed over the Royston Bridge Membrane Primar 713.

10.1.1 Membrane - The Royston Bridge Membrane No. 10 shall have the following properties:

Composition: Heat modified bituminous resin composition with inner layers of open weave fiberglass mesh and polyester top surface.
Color: Black
Thickness: 80 ± 5 mils
Softening Point: Ring and Ball - 240° F to 255° F
Needle Penetration: 30 to 40 at 77° F, 5 Sec. at 100g
Weight per Square Yard: 3.8 to 4.3 lbs.

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10.1.12 Primar - The Royston Bridge Membrane Primar 713 shall have the following properties:

Composition: Synthetic rubber and resin based formulation in an organic solvent system
Color: Black
Weight per Gallon: 7.9 lbs.
Flash Point: 37° F. (Flammable)
Shelf Life: At least one year.

10.2 Certification and Sampling - Certifications and sampling shall be in accordance with paragraph 2.0 of these specifications.

10.3 Surface Preparation - Surface preparation shall be in accordance with paragraph 3.0 of these specificaitons.

10.4 Application - Application shall be in accordance with paragraph 4.0 of these specifications.

SUPPLEMENTAL SPECIFICATIONS
BITUMINOUS MATERIALS

BITUMINOUS MATERIALS: Section 902 of the Standard Specifications is amended as follows.

SUBSECTION 902.02, ASPHALT CEMENT: This Subsection is amended to permit the use of asphalts meeting the specifications of viscosity graded asphalt cements, AASHO Designation: M 226 (modified), as shown on the enclosed amended Schedules 1 and 2.

The contractor has the option of furnishing asphalt cements meeting LDH specifications given in Schedules 1 and 2 of Section 902 or asphalts meeting AASHO Designation: M 226 (modified), until June 30, 1974. After that date, all asphalts furnished will be in accordance with the attached AASHO Designation: M 226 (modified), Schedules 1 and 2.

The asphalt cement grades with allowable substitutions are as follows:

Present LDH Schedules 1 and 2	Attached AASHO Schedules 1 and 2
AC-3	AASHO AC-40
AC-5	AASHO AC-20
AC-8	AASHO AC-5

SUBSECTION 902.03, EMULSIFIED ASPHALT: This Subsection is amended to permit the use of emulsified asphalts meeting the requirements of Schedules 4 and 6 of the Standard Specifications or revised Schedules 4 and 6 that are included herein, until June 30, 1974. After that date, all of these types of emulsified asphalts will be in accordance with these revised Schedules 4 and 6.

SCHEDULE NO. 1 AMENDED TO INCLUDE

ADJUSTMENT IN UNIT PRICE OF ASPHALT CEMENT, MODIFIED AASHO GRADES AC-20 AND AC-40

		AC-20(*1)			AC-40(*1)		
Applicable to Asphaltic Concrete Mixtures		Percent of Contract Unit Price Per Unit of Measurement of Asphaltic Concrete Mix					
		Specifications	Deviations		Specifications	Deviations	
		100%	99%	90% Pay or Remove (*2)	100%	99%	90% Pay or Remove (*2)
Applicable to Asphalt Cement As a Separate Item		Percent of Contract Unit Price Per Unit of Measurement of Asphalt Cement Per Shipment					
		Specifications	Deviations		Specifications	Deviations	
	Test Method	100%	80%	No Pay or Remove (*5)	100%	80%	No Pay or Remove (*5)
Viscosity, 60°C (140°F) poises	AASHO T 202	2000±400		1599- 2401+	4000±800		3199- 4801+
Viscosity, 135°C (275°F) SSF (*6)	ASTM E 102	150+			200+		
Viscosity, 135°C (275°F) Cs	AASHO T 201	300+	250-299	249-	400+	350-399	349-
Penetration, 25°C (77°F) 100g, 5 Sec.	AASHO T 49	65+ (*4)		59-	45+ (*3)		39-
Solubility in Trichloroethylene, %	AASHO T 44	99.0+			99.0+		
Flash Point, COC, °C (°F)	AASHO T 48	232 (450)+		(449-)	232 (450)+		(449-)
Tests on Residue From Thin Film Oven Test:							
Viscosity, 60°C (140°F) poises	AASHO T 202	8000-			16000-		
Ductility, 25°C (77°F), 5cm/min.	AASHO T 51	100+			100+		
Spot Test (Standard Naptha Solvent)	AASHO T 102	Neg.			Neg.		

(*1) All values are inclusive.
(*2) If the material does not result in an inferior or unsatisfactory product, it may remain at 90% pay.
(*3) For samples obtained at point of delivery, the penetration requirement shall be 40+.
(*4) For samples obtained at point of delivery, the penetration requirement shall be 60+.
(*5) If the material does not cause unsatisfactory results, it may remain in place at no pay.
(*6) For samples obtained at point of delivery the viscosity @ 275°F may be determined using ASTM E 102.

SCHEDULE NO. 2 AMENDED TO INCLUDE

ADJUSTMENT IN UNIT PRICE OF SURFACE TREATMENT ASPHALT CEMENT, MODIFIED AASHO GRADE AC-5

AC-5(*1)

Percent of Contract Unit Price Per Gallon of Asphalt Per Shipment

	Test Method	Specifications 100%	Deviations 80%	Deviations No Pay or Remove (*2)
Viscosity, 60°C (140°F) poises	AASHO T 202	500±100		399- 601+
Viscosity, 135°C (275°F) SSF (*4)	ASTM E 102	88+		
Viscosity, 135°C (275°F) Cs	AASHO T 201	175+	125-174	124-
Penetration, 25°C (77°F) 100g, 5 Sec.	AASHO T 49	140+ (*3)		129-
Solubility in Trichloroethylene, %	AASHO T 44	99.0+		
Flash Point, COC, °C (°F)	AASHO T 48	177 (350)+		(349-)
Tests on Residue From Thin Film Oven Test:				
Viscosity, 60°C (140°F) poises	AASHO T 202	2000-		
Ductility, 25°C (77°F), 5 cm/min.	AASHO T 51	100+		
Spot Test (Standard Naptha Solvent)	AASHO T 102	Neg.		

(*1) All values inclusive

(*2) If the material does not cause unsatisfactory results, it may remain in place at no pay.

(*3) For samples obtained at the point of delivery the penetration requirement shall be 130+.

(*4) For samples obtained at point of delivery the viscosity at 275°F may be determined using ASTM E 102.

SCHEDULE NO. 4 REVISED

ADJUSTMENT IN UNIT PRICE OF ANIONIC EMULSIFIED ASPHALT

		Percent of Contract Unit Price Per Gallon of Asphalt Per Shipment					
		SS-1			SS-1h		
		Specifications	Deviations		Specifications	Deviations	
	Test Method	100%	80%	No Pay	100%	80%	No Pay
Viscosity SSF @ 77°F	AASHO T 59	20 - 100	(10 - 19) (101 - 150)	(9-) (151+)	20 - 100	(10 - 19) (101 - 150)	(9-) (151+)
Residue by Distillation, %	AASHO T 59	57 Min.	(52 - 56)	(51-)	57 Min.	(52 - 56)	(51-)
Settlement, 5 Days, %	AASHO T 59	5 Max.	No Penalty		5 Max.	No Penalty	
Cement Mixing	AASHO T 59	2 Max.	No Penalty		2 Max.	No Penalty	
Sieve Test, % Retained on No. 2	AASHO T 59	0.1 Max.	No Penalty		0.1 Max.	No Penalty	
Tests on Residue Penetration @ 77°F, 100g 5 Sec.	AASHO T 49	100 - 200	(88 - 99) (201 - 212)	(87-) (213+)	40 - 90	(30 - 39) (91 - 100)	(29-) (101+)
Solubility in Trichloroethylene, %	AASHO T 44	97.5 Min.	No Penalty		97.5 Min.	No Penalty	
Ductility @ 77°F, cm	AASHO T 51	40 Min.	(26 - 39)	(25-)	40 Min.	(26 - 39)	(25-)

SCHEDULE NO. 6 REVISED

ADJUSTMENT IN UNIT PRICE OF CATIONIC EMULSIFIED ASPHALT

Percent of Contract Unit Price Per Gallon of Asphalt Per Shipment

	Test Methods	CRS-2 (Rapid Setting for Seal) (RS-3K)			Quick Set for Slurry Seal (CQS-1h)			CSS-1h		
		Specifications	Deviations		Specifications	Deviations		Specifications	Deviations	
		100%	80%	No Pay	100%	80%	No Pay	100%	80%	No Pay
Viscosity, SSF @ 122 F	AASHO T 59	100-400	(56-99) (401-444)	(55-) (445+)						
Viscosity, SSF @ 77 F	AASHO T 59				20-100	(10-19) (101-150)	(9-) (151+)	(20-100)	(10-19) (101-150)	(9-) (151+)
Residue by Distillation, %	AASHO T 59	65 Min.	(61-64)	(60-)	57 Min.	(52-56)	(51-)	57 Min.	(52-56)	(51-)
Oil Distillate by Volume, %	AASHO T 59	3 Max.	No Penalty							
Particle Charge	LDH TR 311	Pos.		Neg.	Pos.		Neg.	Pos.		
Sieve Test (Retained on No. 20)	AASHO T 59	0.1 Max.	No Penalty		0.1 Max.	No Penalty		0.1 Max.	No Penalty	
Settlement, 5 Days, %	AASHO T 59	5 Max.	No Penalty		5 Max.	No Penalty		5 Max.	No Penalty	
Mixing & Setting Properties	LDH TR 315									
Mixing, Seconds					120 Min.	No Penalty				
Setting, Minutes					60 Max.	No Penalty				
Tests on Residue										
Penetration @ 77 F, 100g, 5 Sec.	AASHO T 49	100-250	(84-99) (251-266)	(83-) (267+)	40-90	(30-39) (91-100)	(29-) (101+)	(40-90)	(30-39) (91-100)	(29-) (101+)
Solubility in Trichloroethylene, %	AASHO T 44	97.5	No Penalty		97.5	No Penalty		97.5	No Penalty	
Ductility @ 77 F, cm	AASHO T 51	80 Min.	(66-79)	(65-)	40 Min.	(26-39)	(25-)	40 Min.	(26-39)	(25-)
Viscosity @ 275 F, Kinematic, Cs	AASHO T 201	175 Min.	(125-174)	(124-)						

SUPPLEMENTAL SPECIFICATIONS
AGGREGATES

AGGREGATES: The Standard Specifications for Section 903 are amended as follows.

SUBSECTION 903.03, COARSE AGGREGATE FOR CONCRETE:

Heading (a) entitled "Gravel, crushed stone, crushed slag or a combination of gravel and crushed stone" of this subsection is amended as follows.

1. The first paragraph concerning crushed slag aggregate is deleted and the following substituted therefor.

Crushed slag shall be from a source approved by the Department. The slag shall consist of angular fragments reasonably free from flat or elongated pieces, dirt or other objectionable matter. Crushed slag shall not show an abrasion loss of more than 40 percent by the Los Angeles abrasion test and shall not contain more than 10 percent by weight of glassy particles. The crushed slag shall have a minimum dry weight of 70 pounds per cubic foot, and shall be properly cured and stored such that it results in a chemically inert and stable aggregate. Because of its high absorption property, slag in stockpiles shall be kept uniformly wet.

Ten percent glassy particles is considered to be the maximum safe limit for this type construction. A higher percentage may be allowed for slags having demonstrated a satisfactory service record at the discretion of the Department.

2. The sixth paragraph of this heading concerning crushed stone is deleted and the following substituted therefor.

Crushed stone shall be obtained from clean, tough, sound, durable stone. The particles of stone shall be reasonably free from dust, vegetable or other deleterious matter and shall show a percent loss of not more than 40 percent by the Los Angeles abrasion test. Not more than 3 percent of the stone by weight shall be removed by washing over a number 8 sieve. When crushed stone is to be used in a surface course in a pavement or on a bridge deck, it shall show a solubility loss of not over 5 percent by weight when tested in accordance with LDH Designation: TR 115, or an ignition loss of not over 5 percent by weight when tested in accordance with LDH Designation: TR 114. However, the combined loss by these two tests shall not exceed 8 percent by weight. Only materials which have been source approved by the Department shall be used.

SUBSECTION 903.06, BITUMINOUS SURFACE TREATMENT AGGREGATES:

The requirements of Heading (b) entitled "Crushed Stone" of this subsection are amended to include the following.

The crushed stone shall show a solubility loss of not over 5 percent by weight when tested in accordance with LDH Designation: TR 115, or an ignition loss of not over 5 percent by weight when tested in accordance with LDH Designation: TR 114. However, the combined loss by these two tests shall not exceed 8 percent by weight. Only materials which have been source approved by the Department shall be used.

The requirements of Heading (c) entitled "Crushed Slag" of this subsection are deleted and the following substituted therefor.

Crushed slag shall be from a source approved by the Department. The slag shall consist of angular fragments reasonably free from flat or elongated pieces, dirt or other objectionable matter. Crushed slag shall not show an abrasion loss of more than 40 percent by the Los Angeles abrasion test and shall not

contain more than 10 percent by weight of glassy particles. The crushed slag shall have a minimum dry weight of 70 pounds per cubic foot, and shall be properly cured and stored such that it results in a chemically inert and stable aggregate.

Ten percent glassy particles is considered to be the maximum safe limit for this type construction. A higher percentage may be allowed for slags having demonstrated a satisfactory service record at the discretion of the Department.

The requirements of Heading (f) entitled "Gradation Requirement" of this subsection are amended to delete the gradation requirements for size 3 seal coat aggregate in Table VI and substitute the following.

SIZE 3 (SEAL)

U. S. Sieve	Percent Passing (By Weight)
1/2 inch	100
3/8 inch	90 - 100
No. 4	15 - 60
No. 10	0 - 15
No. 16	0 - 5

SUBSECTION 903.07, AGGREGATES FOR ASPHALTIC CONCRETE:

Heading (a) entitled "Type 1 Mixture" of this subsection is amended as follows. The second, third and fourth paragraphs concerning crushed gravel, crushed granite or stone, and crushed slag are deleted and the following substituted therefor.

Crushed gravel shall consist of clean, hard, tough, durable fragments and shall be screened and crushed to sizes as necessary to meet the grading requirements specified herein. Gravel shall not show an abrasion loss of more than 40 percent by the Los Angeles abrasion test. It shall show a soundness loss of not more than 15 percent by weight when subjected to 5 cycles of the magnesium sulfate soundness test.

Crushed granite or stone shall be obtained from clean, tough, sound, durable rock. The particles shall be reasonably free from dust, vegetable matter, or other deleterious matter, and shall not show an abrasion loss of more than 40 percent by the Los Angeles abrasion test. It shall show a soundness loss of not more than 15 percent by weight when subjected to 5 cycles of the magnesium sulfate soundness test. When crushed granite or stone are to be used in a surface course in a pavement or on a bridge deck, they shall show a solubility loss of not over 5 percent by weight when tested in accordance with LDH Designation: TR 115, or an ignition loss of not over 5 percent by weight when tested in accordance with LDH Designation: TR 114. However, the combined loss by these two tests shall not exceed 8 percent by weight. Only materials which have been source approved by the Department shall be used.

Crushed slag shall be from a source approved by the Department. The slag shall consist of angular fragments reasonably free from flat or elongated

pieces, dirt or other objectionable matter. Crushed slag shall not show an abrasion loss of more than 40 percent by the Los Angeles abrasion test and shall not contain more than 10 percent by weight of glassy particles. The crushed slag shall have a minimum dry weight of 70 pounds per cubic foot, and shall be properly cured and stored such that it results in a chemically inert and stable aggregate.

Ten percent glassy particles is considered to be the maximum safe limit for this type construction. A higher percentage may be allowed for slags having demonstrated a satisfactory service record at the discretion of the Department.

Heading (f) entitled "Mineral Filler" is amended to delete the tenth paragraph and substitute the following therefor.

Whenever mineral fillers are to be approved for use in bituminous mixtures, the laboratory shall prepare mixtures of aggregate, filler and asphalt in proportions to meet the requirements of mixes presently being utilized and this mixture shall have an index of retained Marshall Stability of at least 75 percent, and a maximum of 1.0 percent volumetric swell, as determined in accordance with LDH Designation: TR 313.