# BRIDGE DECK REPAIR USING EPOXY RESIN

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Final Report HR-177

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IOWA HIGHWAY RESEARCH BOARD

# FINAL REPORT HR-177

ON

# BRIDGE DECK REPAIR

# USING INJECTED EPOXY RESIN

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FINAL REPORT

BRIDGE DECK REPAIR USING INJECTED EPOXY RESIN

IOWA HIGHWAY RESEARCH PROJECT HR-177

## Project Purpose and Scope

Research funds were approved for the purchase of equipment desinged to proportion and inject epoxy resins into delaminated areas of bridge decks. Through investigation and refining of this process, it was anticipated that a maintenance procedure would be developed to delay spalling of bridge decks by "gluing down" delaminated areas before spalling occurred.

## Conclusions

Results to date would indicate that using a machine for proportioning and pumping epoxy into delaminated areas to delay spalling in bridge decks is a viable maintenance procedure when large delaminated areas are present. Those instances that seem most adaptable to epoxy injection are bridges that have developed delaminated areas but do not exhibit very much spalling.

Bridges with "v" type spalling over reinforcing steel or small (2 to 3 sq. ft.) hollow areas around spalls can be repaired more economically with partial depth PCC patches using low slump concrete.

The use of the machine to proportion and inject epoxy into damaged PC Concrete beams has only limited application. Injection of cracked beams can be more efficiently accomplished mixing small portions of epoxy and using hand tools for injection.

Continued observation and monitoring of repaired deck areas will be required to determine long term results.

Development of epoxies with lower viscosity, longer "pot life" and shorter cure time would increase the adaptability of the machine to our maintenance operations.

## Introduction

Maintenance of spalled bridge decks requires constant surveillance and the commitment of considerable manpower and equipment by maintenance forces. Maintenance cost for deck repair was $68,000 in Fiscal Year 1977 and $83,400 in Fiscal Year 1978.

Patching of spalled areas with bituminous material is a temporary repair, at best. It will help reduce traffic impact loadings on the structure but will do nothing to prevent further deterioration of the decks. It is usually noted that concrete around the spalled area delaminates (or is delaminated at the time the bituminous material is placed) this, in turn, spalls out increasing the area of deterioration.

A more permanent repair of a spalled area can be accomplished by removing all deteriorated concrete as well as all delaminated areas around a spall and patching with low slump, PC Concrete.

In 1974, the Kansas State Highway Department published a report on "Repair of Hollow or Softened Areas in Bridge Decks by Rebonding with Injected Epoxy Resin or Other Polymers." This report described in detail the development of a machine to properly proportion epoxy resin and inject the epoxy under low pressure (20 to 50 psi) into delaminated areas thereby rebonding the layers of concrete. Epoxy injection of delaminated bridge floors had been used by Kansas previously, however, it was a very slow, messy operation. Epoxy was either mixed in small batches or the components were placed in grease guns and then injected. With the development of the machine for proportioning and injecting the resins, it appeared that this method had considerable promise as an alternate to our current method of floor repair which involved removal of deteriorated or delaminated concrete and patching with low slump PC Concrete.

In 1975, the Maintenance Department requested, and the Iowa Highway Research Board authorized $3,000 for acquisition of an epoxy injection machine for the Topeka Foundry and Iron Works of Topeka, Kansas. This company worked with the Kansas Highway Department in developing the original machine and was now producing them commercially.

Implementation

In August of 1975, the epoxy injection machine was received from Topeka Foundry and Iron Works.

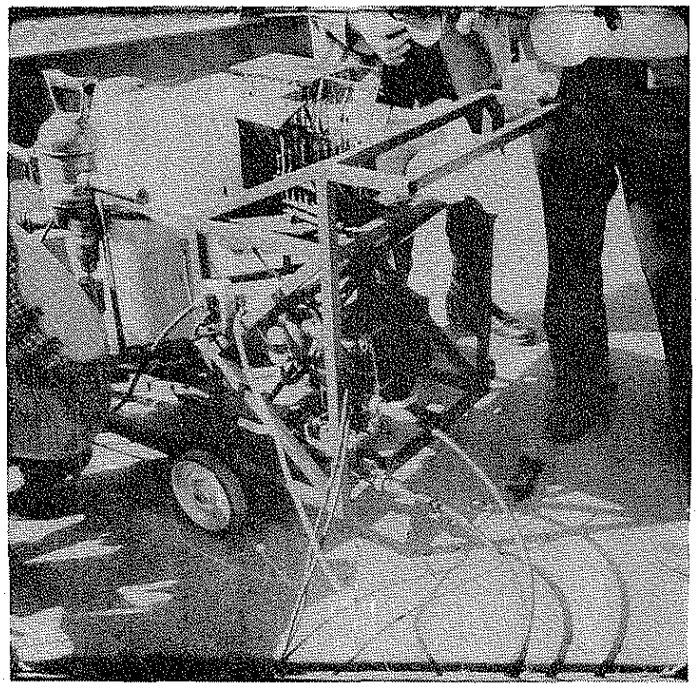

Figure 1
Injection Pump and Drill Unit

The unit consisted of; two reservoirs for the epoxy resins; two positive displacement pumps driven by a common electric motor using chains and sprockets to obtain the desired drive ratio to accomplish the metering and pumping; a mixer-probe for injecting the epoxy. The mixing is accomplished when the resins pass through the brush ends of four test tube cleaners in the injection probe. The equipment package also included a ½ H.P. electric-drill fitted with a swivel, vacuum collet, a 2½ H.P. industrial vacuum cleaner and one hundred 9/16 inch carbide tipped, hollow drill bits.

The first bridge selected for injection was the east-bound bridge over Ia 146 on I-80 at the Grinnell interchange. This is a 214 ft. x 30 ft. prestressed concrete beam bridge constructed in 1962 and overlayed with dense concrete in 1971. This bridge deck had developed some large "hollow" areas. Previous investigation had disclosed that the delaminations were in the original concrete and not in the bond line between the overlay and the old concrete.

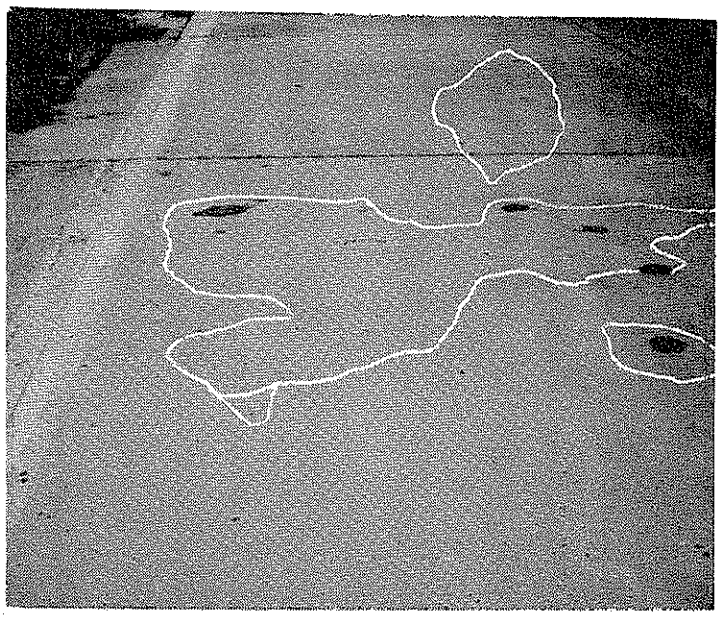

Figure 2
Delaminated Areas are Outlined

Hollow or delaminated areas were located using a chain drag and then outlined with chalk after sounding with a hammer to pinpoint the edges of the area.

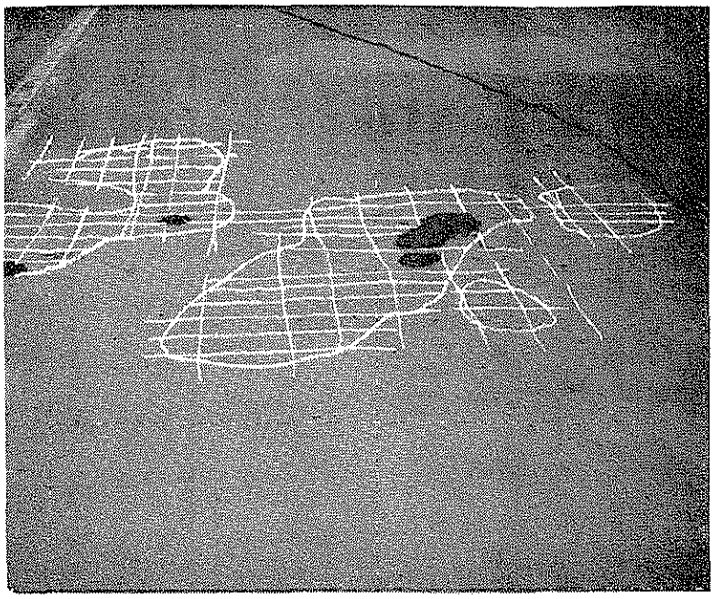

Figure 3
Location of Reinforcing Steel Marked

A pachometer was used to locate the reinforcing steel in the area so that it could be avoided to prevent damage to the drill bits when drilling the injection ports.

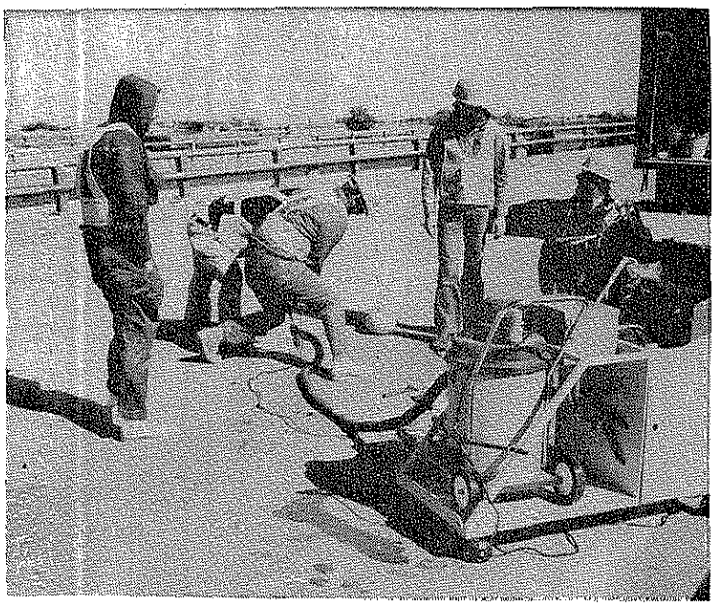

Figure 4
Drilling Injection Holes With Vacuum Attached

Holes for injection were drilled through the plane of delamination on approximately 2 ft. centers prior to commencing the repair. Sinmast injection resin was selected for this bridge in as much as the Kansas report indicated it was satisfactory for this procedure. By tapping the deck during the injection process, the flow of epoxy could be determined.

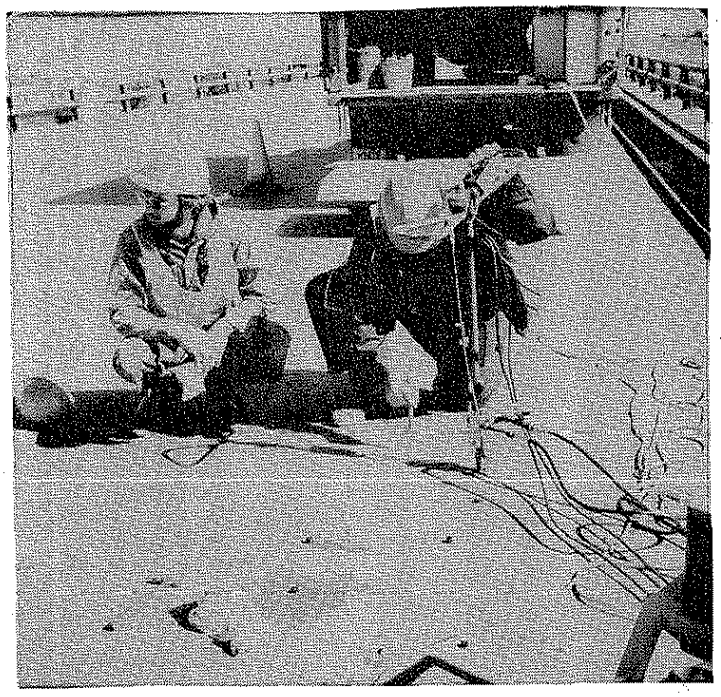

Figure 5
Injecting Epoxy and Checking Flow in Delamination
by Tapping with Small Steel Rod.

If an obstruction to the flow occurred, additional holes needed to be drilled. These additional holes must be drilled outside the area that the epoxy had penetrated. We soon learned that only a small amount of epoxy sucked

up by the vacuum with the cement dust through the hollow drill bit not only plugged the bit, but also the ports on the suction collar on the drill. Sixty-six gallons of Sinmast injection resin were used in rebonding 1430 square feet of bridge deck. The delaminated areas ranged in size from approximately one square foot to 100 square feet. A four-person crew was used for two weeks on the project for a total cost of $3,174 or approximately $20 per square yard of area rebonded.

Epoxy injection of the delaminated areas on the west-bound bridge over the Des Moines River on US 30 near Boone was also attempted. The bridge is a 717 ft. x 30 ft. steel deck girder constructed in 1963. There were numerous small "v" type spalls and small hollow areas on this deck. Almost all of the hollow areas were six to eight inches wide and one to three feet long and centered over a reinforcing bar. After repairing approximately 514 square feet of hollow areas, work was stopped on this bridge because of cold weather. We had also concluded that repair of delaminated areas such as were present on this bridge did not lend themsleves to this procedure. Too much time was spent drilling holes for the small areas repaired. It was also very destructive of drill bits since the carbide tips were dulled immediately on contact with the reinforcing steel. Approximately 19 gallons

of resin were used in injecting 514 square feet of delaminated areas during a period of eight days at a cost of $30.00 per square yard. The epoxy resin used was Colmadur-L.V.

Repair of a concrete beam on a bridge over US 34 that had been hit and damaged by an overheight load was also attempted, but because of problems encountered, it was concluded that the machine was not suitable for this operation. The major problem being that the flow of epoxy into the fine cracks in the beam was so slow that epoxy setup in the mixing chamber. It took two days to drill the hardened epoxy out of the mixer head.

In the summer of 1978, it was found that the deck of the bridge over the Des Moines River on Ia 46 at the south edge of Des Moines was delaminating under the dense concrete resurfacing. This bridge is a multi-span high truss constructed in 1938. At the time the floor was resurfaced, it was recognized that the original concrete deck was of questionable quality and very possible that the resurfacing would not remain bonded. There apparently has been additional deterioration of the original deck. The district bridge crew, in a two week period, injected 32 gallons of epoxy resins while filling delaminated areas in approximately 40 sq. yds. Since this represented only about 25% of the delaminated areas, further work was halted until the areas that had been completed could be evaluated.

No epoxy injection work was done in 1978 because of needed repairs on the epoxy pump and mixing head. It is planned, however, to repair delaminated areas on additional bridges in the summer of 1979 if funds are available for this type of maintenance.

Summary and Recommendations

There has been only a limited opportunity to use the epoxy injection process to rebond delaminated areas in bridge decks, however, results to date would indicate that there are instances where this repair procedure can be used advantageously. Bridge decks having relatively large delaminated areas and very little spalling would be recommended candidates for repair by the epoxy injection method.

Continued monitoring of the bridge deck on I-80 near Grinnell will be necessary to determine the longevity of the repair. A year and a half after this repair was completed, it was estimated that 80% of the area remained "glued together". There has been very little change since then.

Additional training for personnel in the use of the machine and familiarization with the procedures will be required to increase efficiency in accomplishing the rebonding, but it is believed that the procedure has definite application in bridge deck maintenance.