were noticeably smoother. Friction testing will be performed in the future to determine changes with time under traffic and to determine whether any corrective action may be necessary.

CONCLUSIONS

A bonded concrete overlay can be constructed while traffic is maintained on adjacent lanes and shoulders of this six-lane highway.

An adequate bond was achieved by using surface preparation consisting of scarification, sandblasting and cleaning, and a portland-cement and sand bonding grout.

As shown during construction, pressure relief in the existing pavement is necessary before the overlay is constructed.

To reduce delays in transporting concrete due to traffic and haul times and for faster response to problems, an on-site concrete plant is necessary.

Control of dust generated by the surface-preparation stage, although improved during the project, needs additional work on equipment development. Further work is also needed on equipment limitations and tolerable dust limits so that practical specifications for dust control may be developed.

Acceptable results on roughness, as measured by a profilograph, have been obtained.

Overall rideability of the overlay, as shown by New York State's present rideability index, was excellent.

Friction testing with New York's locked-wheel pavement friction-testing trailer generally showed acceptable friction numbers. Nevertheless, additional future testing is necessary to determine changes with time and any necessary action on some low test values found.

After exposure to one winter, including 8.5 months of traffic, the expected reflection cracks and the narrow transverse cracking, which occurred during hot weather, had not created any problems.

To determine project performance for cost-effectiveness, the overlay should be monitored annually for at least 5 yr.

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Portland-Cement Concrete Inlay Work in Iowa

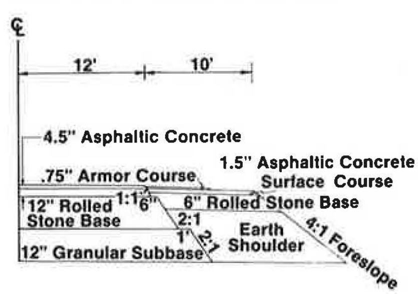
GEORGE CALVERT

High maintenance costs and continuing inconvenience to the traveling public have forced Iowa to take drastic measures in resolving a long-standing problem on Interstate 80 in western Iowa. It was found necessary to remove a section of asphalt and replace it full width with a portland-cement concrete section 10 in. deep. The removal and replacement operation led to the conclusion that in the future major problems could be corrected by replacement of the 12-ft travel lane only. Construction of the 12-ft travel lane proved to be cost-effective and no major problems were encountered. Through traffic was maintained in the normal passing lane and the contractor was limited to use of the 10-ft outside shoulder only. Included are details of the reasoning leading to the decision to reconstruct the travel lane only. Minor problems associated with smoothness of ride were corrected by use of a heavier finishing machine.

During the height of Interstate construction in Iowa in the late 1950s, a section of Interstate approximately 13.7 miles long was constructed through Adair, Dallas, and Madison Counties by using existing design practices for the construction of asphalt pavements. This section of roadway was constructed by using 12 in. of crushed-stone granular subbase overlaid with 12 in. of rolled-stone base followed by 3 in. of asphalt binder material and 1.5 in. of asphalt surface course. This construction was completed in 1959 and opened to traffic in 1960 (Figure 1).

This section of I-80 is now handling approximately 15,000 vehicles/day; trucks make up 35 percent of this traffic. Many of them are cross-country, heavy semitrailer loads. Because of the type and volume of traffic as well as because those grades were laid to a lower standard than that used now and the water table is higher than desirable, it was recognized that this was an inadequate design.

Figure 1. Interstate construction, 1958.

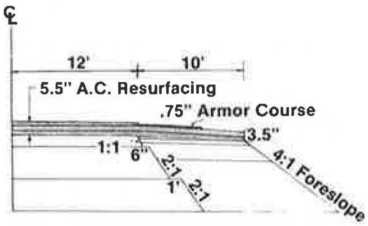


FIRST OVERLAY

The enormous buildup in cross-country truck traffic and the high water table caused premature damage to this thin section. A major overlay with asphalt materials was scheduled in 1964. With the encouragement of both FHWA and the asphalt industry, this section of roadway was overlaid with 5.5 in. of asphalt material, which included a 2-in. leveling course and a 2-in. layer of binder course. Both courses had a maximum particle size of 1.5 in., which caused some problems. This was overlaid with 1.5 in. of 3/4-in. surface course (Figure 2).

The problem encountered with the 1.5-in. leveling and binder course was based on the use of a limestone aggregate. Because this aggregate had relatively high absorption, it was difficult to completely dry the particles that were between 0.5 and 1.5 in. The particles continued to give off mois-

Figure 2. Overlay of Interstate pavement, 1964.



ture even after they had been taken from the dryer and had been coated with asphalt. The result was bad stripping of the coarse aggregate particles even at the time of laying. This did not cause concern, even though there was an enormous drop in temperature between the mixing operation and the actual laying operation, because the moisture was driven off and condensed; it actually streamed out of the trucks. The reason for the lack of concern was that while the material went through the spreading operation, the paving hoppers, and the auger systems, it appeared that the coarse aggregate particles were being recoated. They lost their brown color and reverted to a blacker shade as the asphalt was redistributed on them. This, however, laid the groundwork for future problems.

When this 4-in. layer of 1.5-in. maximum-size particle mix was consolidated and the surface course was put on top, it was discovered within a matter of months that there were further problems with stripping of the coarse aggregate particles. This was caused by the heavy-truck traffic and the high moisture table, which fed large quantities of water into this layer. The hydraulic pressures exerted on these particles by repeated truck loadings and the presence of excessive amounts of water caused stripping. The surface shoved badly in those areas where stripping occurred and where the binder-level courses lost their strength.

SECOND OVERLAY

These premature failures the second time caused a desperate attempt in 1970 to remedy what appeared to be a bad situation. Still more asphalt was placed on top of this section--an additional 2 in. of binder course and a 1-in. surface course (Figure 3). By this time the mainline roadway was approaching a thickness of about 13 in. of composite asphalt, a reasonable design section for the traffic volume. The problem was that each of the layers had broken up before being overlaid, so the composite thickness was not nearly so impressive as it should have been because each succeeding layer had failed at an early date.

Again this 3-in. asphalt overlay lasted a few short years and the roadway started to show failures due to the underlying 4 in. of 1.5-in. mix. There was insufficient asphalt overlay over this material to support the heavy truck loading, and continual stripping of this aggregate in the saturated condition caused failures to work through the surface.

The traveled lane showed the worst distress and the passing lane showed little distress. The shoulders in this section, which were now a total of 10 in. thick, showed no distress at all. These layers had not failed, so there was 10 in. of good asphalt on the shoulders throughout the entire project. There was almost continual failure for the full 13.7-mile length of this project in the truck lane. There were only isolated spots of failure in the passing lane, where the moisture table was higher, and at one location on the inside of a superelevated curve.

Figure 3. Additional overlay of Interstate pavement, 1970.

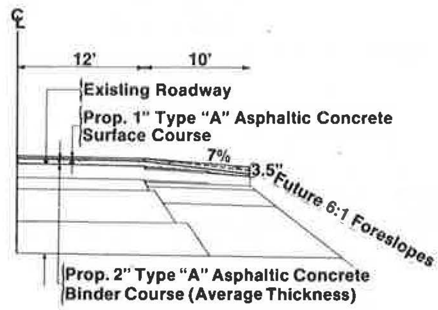


Figure 4. Trenching 42 in. deep for placement of longitudinal drain.

By the late 1970s it was obvious that the previous approach to a permanent solution to this problem was in error. Additional overlays of asphalt were forcing the elevation of structures to maintain clearance, and any solution to the problem was temporary in nature. The engineering staff of the Iowa Department of Transportation did much brainstorming to effect a permanent repair on this section of roadway.

INSTALLATION OF LONGITUDINAL DRAINS

There was some disagreement on a permanent low-maintenance repair, but the staff was unanimous that the water problem must be solved first. A part of any repair instituted would involve installation of longitudinal drains in porous backfill, which would drain the bottom of the lower lift of crushed stone. The plan called for cutting a trench from the surface to the bottom of the crushed stone approximately 42 in. deep and 10 in. wide as the first stage of construction on this project. This trench was to be located under the outside edge of the slab for the full length of the project (Figure 4). The material removed with the trenching operation was to be placed over the outside 10-ft shoulder edge to form a rock fillet in this area. The longitudinal drain was then to be placed 3 in. above the bottom of the trench and the porous backfill was placed over it to near the lower surface of the roadway. This proved to be a satisfactory method of lowering the water table and keeping it to a much more acceptable level under the roadway surface (Figure 5).

CONSTRUCTION OF INLAY

After much discussion, it was agreed to mill out the

Figure 5. Installation of longitudinal drains, 1979.

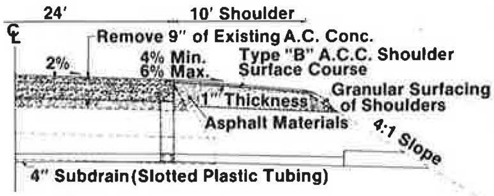


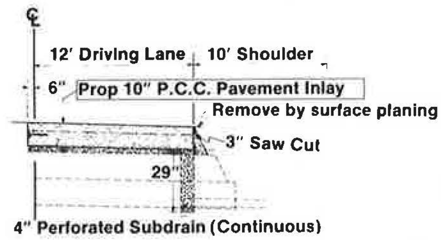
Figure 6. Milling asphaltic concrete 10 in. deep and 12.5 ft wide.

top 9 in. of the asphalt now in place down to the bottom of the questionable 1.5-in. maximum-size particle mix that had caused problems because of stripping and shoving. This made a trench 24 ft wide and 9 in. deep for the 6-mile project from the Redfield interchange west to the Stuart interchange. Nonreinforced concrete paving was then placed in this trench area to a depth of 10 in. Load-transfer devices were placed in joints at 15-ft intervals. The asphalt-concrete material removed was stockpiled for recycling on other projects in the area.

During the milling and removal of the 9 in. of asphalt, it became apparent that the passing lane was not nearly so deteriorated as the traveled lane. The contractor was allowed to use the 10-in. asphalt shoulder for construction traffic, and this worked well. There were no failures or signs of distress on the shoulder during the hauling of the wet batches out to the paving job. The shoulder material had been built up over the years as the mainline was overlaid. Even though the shoulders had showed no distress, it was necessary to keep them up to grade to have a uniform cross section. This was a stable, strong shoulder that was not to be wasted on this or future projects. It was planned, therefore, to pave the mainline 1 in. higher than the shoulders and, after the paving had been completed, to bring the shoulders up to match the edge of the portland-cement concrete inlay with asphalt material. Consequently, the inside 6-ft and outside 10-ft shoulders were overlaid with 1 in. of asphalt.

The 10-in. concrete inlay in the center 24 ft had as a base 4.5 in. of asphalt, which was laid during the initial construction in 1958, underlaid by 2 ft of crushed stone. It was believed at that time, which has since been confirmed, that this section would provide sufficient strength so that little maintenance would be required in the future. To date there has been no distress or problems with this mainline paving or the shoulders on this project. The shoulders on this section of roadway now consist of 6 in. of rolled-stone base overlaid by 11

Figure 7. Construction of inlay, 1981.



in. of various courses of asphalt, all of which are performing well.

The design and construction of this section of roadway involved a learning process from which there has been considerable benefit. This was a small segment of the total problem in this area. It was discovered during the construction of this inlay project that the passing lane was in relatively good condition; there were failures only in isolated areas. Successive overlays of asphalt had left a good section of asphalt and crushed stone in this area. The shoulders were in excellent condition and were to be salvaged if at all possible. The engineering staff was still faced with the problem of what to do with the remainder of this roadway.

In discussion sessions, it was decided to take the bold step of replacing only that section of roadway that was badly damaged. This decision was made because of a lack of funds to replace the full roadway width and the firm belief that by replacing only the traveled lane, the immediate problem could be solved. The other half of the roadway could be replaced at a later time with little additional cost.

The project began at the western termini of the 24-ft inlay at the Stuart interchange and extended west of the I-25 interchange, a distance of slightly more than 8 miles. In this instance, it was decided to inlay 10 in. of concrete 12.5 ft wide. This extended the new concrete inlay over the centerline joint 6 in. and, it was hoped, would mitigate the problem of maintaining the centerline joint. This time 10 in. was milled and removed in order to match the centerline joint and the shoulder profile (Figure 6). It was planned to true up the longitudinal profile of the 10-ft shoulder edge and the centerline before the 12.5-ft trench 10 in. deep was milled and removed. This proved to be a good operation also and made it much easier for the padline of the paver to run on a good profile surface. A longitudinal drain was again placed under the outside shoulder of the slab to drain water from the base and subbase sections. The end product again provided 24 in. of crushed stone topped by 3.5 in. of old asphalt and 10 in. of portland-cement concrete. This total thickness is more than adequate to provide a roadway section that will require minimum maintenance in the future (Figure 7).

To provide for possible future replacement of the inside lane, a keyed tied joint was placed the full length of the project near the centerline of the new pavement. If the passing lane needs to be replaced in the future, it can be milled out and replaced and the tie bar can be straightened out on the keyed tied joint assembly to tie in the two lanes of roadway (Figure 8).

This turned out to be a structurally adequate design. The contractor had problems with equipment early in this project, which caused some rough pavement that had to be corrected. If future designs of this type are used, the industry has the necessary expertise to produce a good inlay.

Figure 8. Tie bars in key and dowel assembly at centerline.

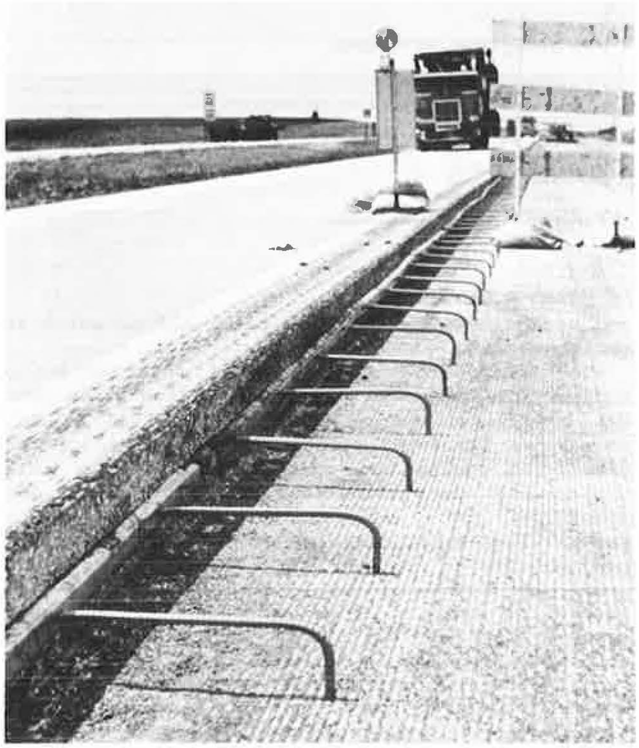


Figure 9. Finished portland-cement concrete inlay.

This project was constructed under traffic. The contractor was required to restrict operations to the trenched area plus 2 ft of adjacent roadway and to keep construction traffic on the 10-ft shoulder (Figure 6). This worked well and brought about a real cost savings. Where traffic volumes are as low as they are on this section--approximately 12,000 vehicles/day with 27 percent trucks--this procedure is adequate.

CONCLUSIONS AND RECOMMENDATIONS

It is believed that there is considerable merit in repairing only that part of the roadway that is extensively damaged. In this instance, and on the many hundreds of miles of Interstate showing distress in the traveled lane only, there is real justification in repairing the distressed section only. Replacing a 12-ft lane as opposed to replacing 40 ft of roadway is obviously a cost savings. Iowa strongly recommends that other states consider reconstruction of the traveled lane only. Potential cost savings nationwide are enormous.

Traffic control is costly when a full 24-ft roadway is being replaced. The ease of doing this under traffic with minimum disruption to the traveling public has been demonstrated on this project; the technique will be used on other projects with the cooperation of FHWA. The replacement of only the 12-ft traveled lane on other sections of Interstate is being considered in Iowa. Such sections may be replaced with materials other than portland-cement concrete through the recycling process (Figure 9).

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