PORTLAND CEMENT CONCRETE OVERLAYS OF EXISTING ASPHALTIC CONCRETE SECONDARY ROADS IN IOWA

Carl F. Schnoor, P.E., Boone County, Iowa Engineer
E.J.Renier, P.E., Senior Regional Engineer-Paving, Portland Cement Association, Minneapolis, Minnesota

Forty-two kilometers (22 mi.) of existing asphaltic concrete low-volume roads were resurfaced with portland cement concrete in five counties of Iowa during 1977. In two counties, complete removal of the old asphalt surface was required prior to repaving with portland cement concrete. In the other three, the old asphalt surface was retained as a base for the new pavement. This paper discusses procedures developed to establish and control grade and portland cement concrete overlay thicknesses in the cases where the old asphalt was retained. On one project grade was established and minimum thickness retained by use of a computer. Economics of design and construction procedures were determined by county engineers. Projects were approved by the Iowa Department of Transportation prior to construction. Thickness monitoring and required equipment modification was accomplished by contractor development and cooperation. The resulting pavements show that portland cement concrete overlays can be successfully constructed over existing asphaltic concrete roads on low-volume secondary systems with a minimum of surface preparation and can contribute a long-term economical solution to the ever-increasing cost of maintenance.

By September of 1978 county engineers in Iowa had constructed over 6,700 km (4,171 mi.) of concrete pavement on the Secondary Roads System of the State. This construction has taken place throughout the State as shown in Figure 1. Earlier papers (1, 2) have been written regarding the performance and related maintenance costs of this system.

During the past 10 years, several county engineers in Iowa have begun to reanalyze the economics of resurfacing procedures used on their asphalt-paved secondary roads in an attempt to decrease maintenance costs and lengthen the required maintenance cycle. Their analysis has resulted in the construction of portland cement concrete overlays over old asphalt county roads (3, p.15) in a number of counties.

Figure 2 was produced from original data obtained in 1972 by W.G.Bester, Portland Cement Association Paving Engineer in Iowa at that time. It shows the effect that an increase in portland cement concrete mileage had on maintenance costs on the low-volume system in one Iowa County.

In 1977, 34.4 km (22 mi.) of asphalt roadway was resurfaced with portland cement concrete in 5 counties. In general, these asphalt roads were some 20 years or more in age and had been resurfaced or seal-coated one or more times during the interim. This paper directs itself to the techniques used for construction of the 5 overlay projects built in 1977.

Two fundamental construction procedures were employed. County engineers in Clinton and Cedar Counties opted for complete removal of the old asphalt surface prior to resurfacing with portland cement concrete because the existing surface exhibited extensive deterioration and distortion. In both cases, after asphalt removal, the existing rolled-stone base was fine-graded prior to PCC paving. The old asphalt material was salvaged and used to upgrade the shoulders. Following removal of the old asphalt, grading and paving procedures followed Iowa's standard slip-form paving requirements for the County Road System. In both cases, the minimum thickness for the portland cement concrete

Figure 1. Distribution by county of portland cement concrete pavement on the county road system in Iowa.

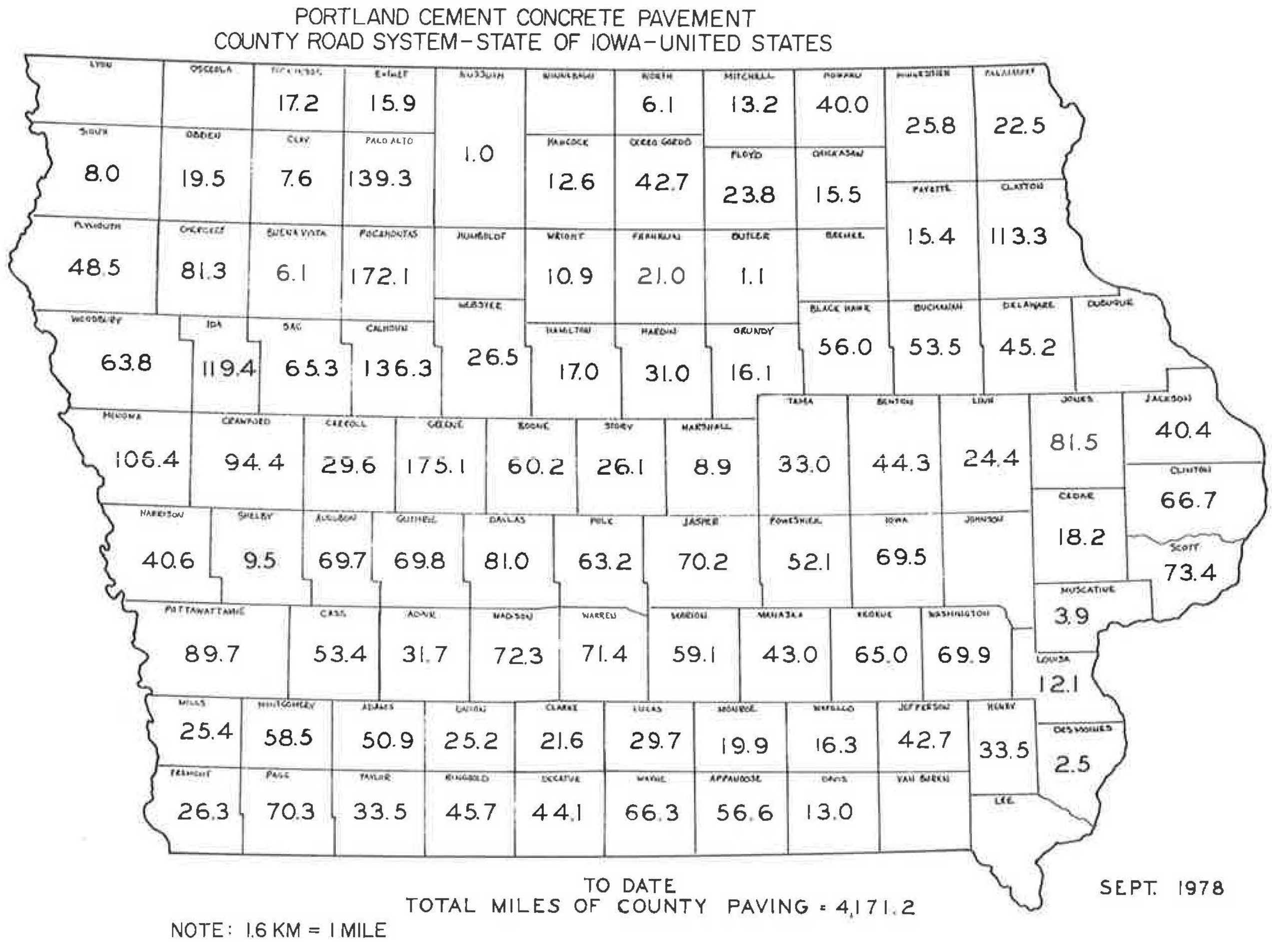
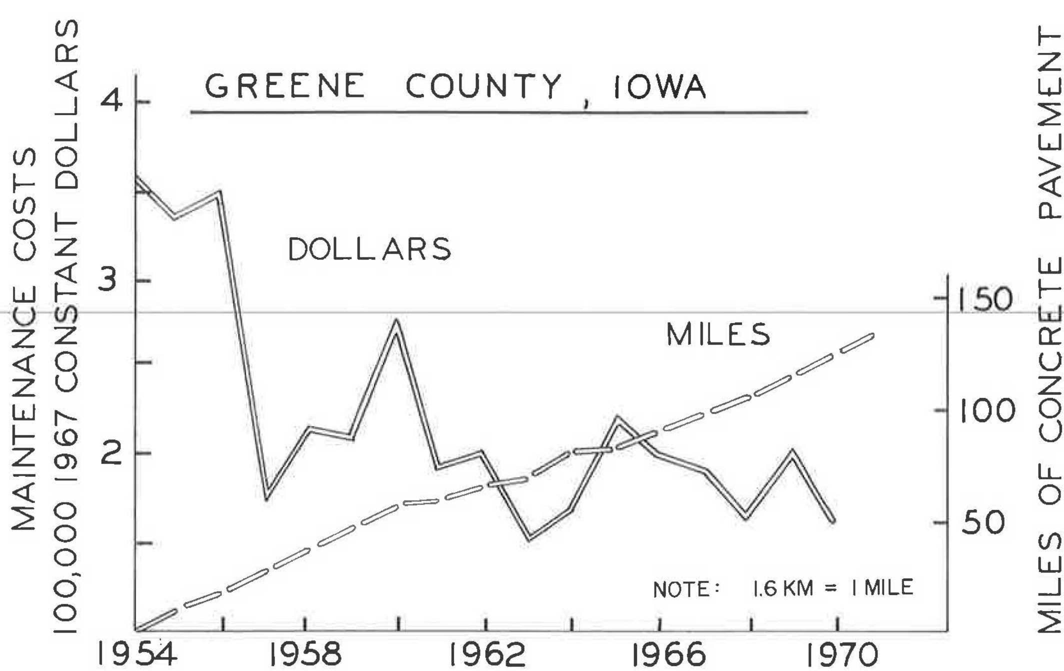


Figure 2. A reduction in maintenance expenditures occurred as the miles of portland cement concrete increased in Greene County, Iowa.



pavement was specified at 152 mm (6 in.).

In Dallas County, Washington County, and Boone County, the county engineers retained the existing asphalt surface as a base under the new portland cement concrete pavement. In all cases, the resulting concrete paving has been excellent. Resurfacing with portland cement concrete directly over the old asphalt required different construction techniques in each case - with each county engineer determining the best procedure to follow for the overlay construction.

Dallas County

In May of 1977, a 1.6 km (1 mi.) project in Dallas County was awarded to the Hallett Construction Co. for the resurfacing of a 76 mm (3 in.) asphaltic concrete mat, which had been placed over 203 mm (8 in.) of rolled-stone base in the mid-1950's. The original pavement had been built 6.7 m (22 ft.) wide and geometric standards at that time allowed the use of narrow shoulders. Because of the narrow shoulders, the contractor was required to widen them prior to the construction of a pad-line for the slip-form paver. The general condition of the asphaltic concrete pavement is shown in Figure 3.

Figure 3. Close-up of the surface, showing general condition of the roadway at the time the overlay was placed.

The roadway to be resurfaced with portland cement concrete had an extremely high crown. Approximately 25.4 mm (1 in.) of this crown was removed with a Gallion road planer as shown in Figure 4.

The Gallion planer cut to a width of 762 mm (30 in.) at centerline and an additional pass was then made on each side of the centerline cut to feather the surface into the existing profile. Grade pins were then set at 15.2 m (50 ft.) intervals on centerline and grade established by stringline. This stringline controlled a CMI tripod auto grader, which in turn established the pad-line for the slip-form paver on each side of the road.

Figure 4. A Gallion road planer was used to reduce the crown 2.54 cm (1 in.).

Specifications required the placement of a nominal depth - 152 mm (6 in.) portland cement concrete resurfacing. In addition, it was required that a minimum thickness of 127 mm (5 in.) and a maximum thickness of 178 mm (7 in.) be retained.

At bridges and intersections, approximately 30.5 m (100 ft.) of the old pavement was completely removed and the new grade established by stringline to meet existing bridge decks or intersecting pavement sections.

The concrete for this project was produced in a central-mix plant and transported to the job-site in dump trucks. It was then deposited directly on the asphaltic concrete surface. The slip-form paving operation was no different than that used to produce the 6,700 km (4,171 mi.) of portland cement concrete roads already in existence in the State. No new or sophisticated equipment was added. A 152 mm (6 in.) thick Iowa Department of Transportation Type B mix was used for the plain concrete pavement which was constructed 6.7 m (22 ft.) wide with transverse joints sawed on 6.1 m (20 ft.) centers.

The only steel used in the project were 762 mm (30 in.) long 13 mm (1/2 in.) diameter deformed tie-bars, which were placed at 0.9 m (3 ft.) centers at the centerline longitudinal joint. This project was used as a detour during construction of a near-by state highway and an inspection made following this additional loading showed it to be in excellent condition. The successful bid on this project was submitted by the Hallett Construction Co. at \$6.42 per m^2 (\$5.37 per sq.yd.).

Washington County

In August of 1977, Washington County, Iowa resurfaced 14.5 km (9 mi.) of existing asphaltic concrete pavement with a nominal 165 mm (6.5 in.) thick portland cement concrete overlay. The original pavement was built in 1958 and consisted of 102 mm (4 in.) of sand base topped with 152 mm (6 in.) of rolled-stone base and 64 mm (2½ in.) of Type B Iowa specification "Asphaltic Concrete Surfacing".

In designing the new grade, the county engineer cross-sectioned the existing roadway every 30.5 m (100 ft.)and entered the data into a 9830 Hewlett Packard computer. Minimum thicknesses of 152 mm (6 in.) at

Figure 5. The computer printout provided centerline elevation from which required grade was established every 30.5 m (100 ft.). It also computed cross-section area every 30.5 m (100 ft.) and totalled required project quantities.

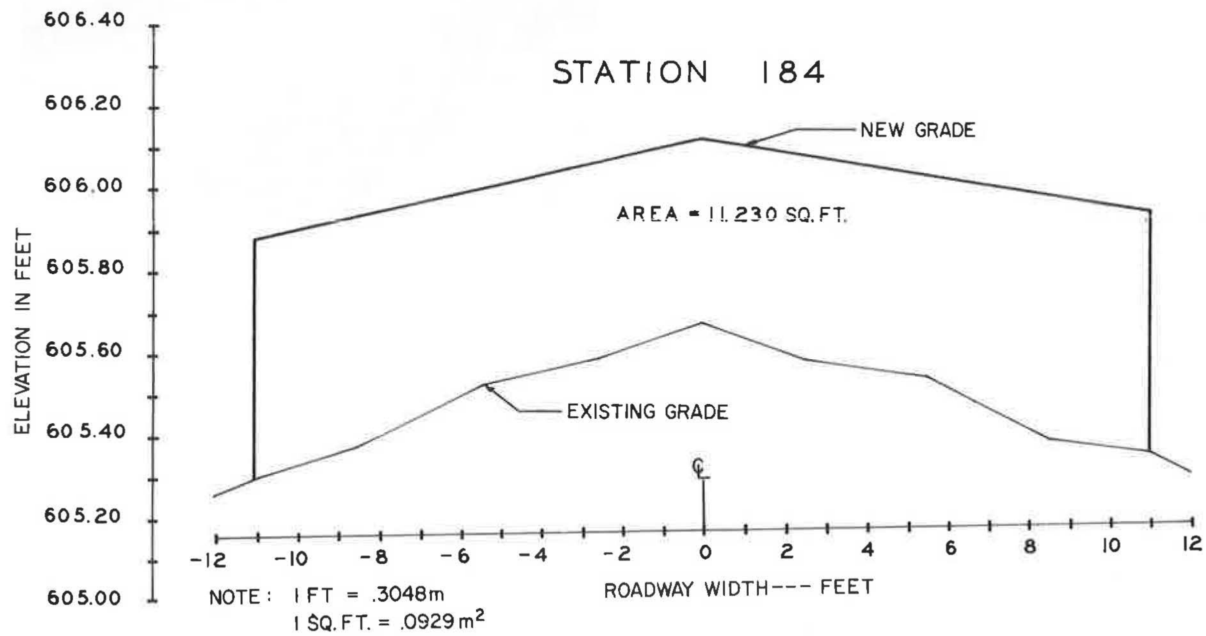


Figure 6. Depicts the entire pavement train including the process of concrete delivery. Note stringline placement.

the outside edge of the roadway and 127 mm (5 in.) at the centerline were required. The existing asphaltic concrete pavement was 7.3 m (24 ft.) in width. The new portland cement concrete overlay was constructed at 6.7 m (22 ft.) wide. With these design restrictions, the average section was built 152 mm (6.5 in.) thick at the outside edge and had a 64 mm (2½ in.)crown.

The computer then plotted the design cross-section every 30.5 m (100 ft.) and established the final grade from which the slip-form paver would operate. A sample computer plot is shown in Figure 5.

The Fred Carlson Co. of Decorah, Iowa was low bidder on the project at \$6.60 per m^2 (\$5.52 per sq.yd.).

The first construction procedure consisted of brooming the existing surface and establishing the computer-determined final grade by stringline. The stringline was established on the right-hand side of the roadway in the direction of paving. After the stringline was in place concrete was delivered to a Rex slip-form paver from a central-mix plant by both dump trucks and agitator trucks and was deposited directly on the old surface in front of the paver. The only piece of slip-form equipment required was the paver itself. No fine-grading was necessary. Figure 6 shows the paving train.

The low-slump portland cement concrete did not slide on the existing asphalt pavement in front of the paver and tearing did not occur in the new pavement surface behind the paver. An inspector operating from a bridge towed by the paver checked pavement thickness at each edge and at the centerline of the plastic portland cement concrete overlay a minimum of once per station. A depth probe, consisting of a slender steel rod operating in a hollow steel tube with a washer-type device to hold the tube at the surface of the slab, was used to check depth. See Figure 7.

Figure 7. A depth probe device was used for measuring the thickness of the resurfacing. The washer-type device is shown at the surface of the plastic concrete with the steel rod inserted into the concrete.

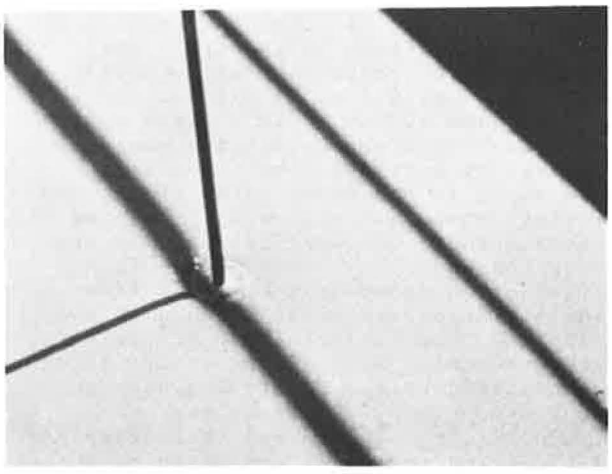
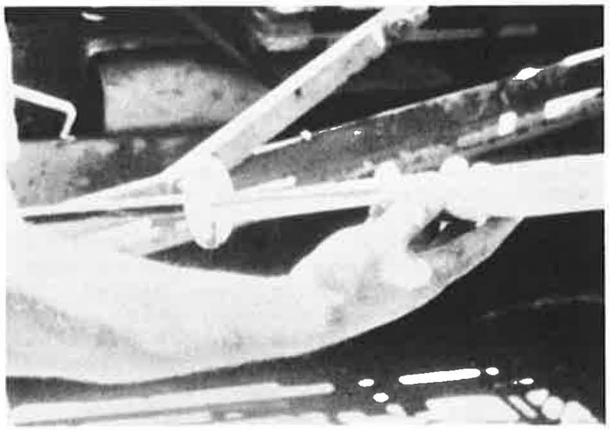


Figure 8. The inspector measured the depth of penetration on the probe with a ruler.



The portion of the rod that penetrated into the plastic concrete was then very easily checked for length as shown in Figure 8 to assure that proper thickness was being obtained. This simple, but accurate device, provided the contractor with continual information regarding overlay thickness while the concrete was still in a plastic state.

The Rex paver towed an astro-turf drag which produced the microtexture in the new surface. The paver also towed a combination bridge from which a transverse combed texture was applied following the astro-turf drag. This last piece of equipment also incorporated the curing operation. Curing was accomplished by application of white membrane curing compound. This operation is shown in Figure 9.

Figure 9. Curing compound was also applied at the edge of the slab. The two pieces of equipment -- Rex slip-form paver, plus combination bridge and equipment -- provided combing and curing.

The new pavement was opened to local farm traffic as soon as flexural test beam breaks indicated that specified strengths had been reached. Both transverse and longitudinal joints were sawed. Deformed 13 mm (1/2 in.) diameter tie-bars 762 mm (30 in.) long were placed at .9 m (3 ft.) centers across the centerline. Very little edge slump occurred as the water content was kept to a minimum in the mix design in recognition of the fact that none of the internal concrete water would be absorbed by the grade.

The completed portland cement concrete pavement was produced in a minimum of time -- over 1,737 m (5,700 ft.) was placed the day following a down-pour, which brought all other construction in the area to a complete halt -- as the procedures used minimized handwork and finishing problems. The resulting pavement had a present serviceability index in excess of 4.5. Crushed rock shoulders were added by county crews prior to opening the roadway to through-traffic.

Figure 10. General condition of the existing asphaltic concrete pavement at the time of overlay with portland cement concrete.

Boone County

In Boone County, Iowa many miles of asphaltic concrete pavement, about 20 years of age, were structurally failing and in need of more than a "cover up" in order to provide additional satisfactory service. The county engineer and Iowa Department of Transportation design personnel determined that a minimum of 127 mm (5 in.) of asphaltic concrete was needed as an overlay to the existing asphalt pavement to provide sufficient additional strength for continued use.

Accordingly, in 1976, Boone County awarded a resurfacing contract requiring the placement of a 127 mm (5 in.) asphaltic concrete overlay over a portion of this mileage. The resulting cost in 1976 was approximately $62,000/1.6 km (1 mi.).

Experience had shown that in Boone County this type of construction would require a seal coat in 5 to 7 years and an additional plant-mixed asphalt overlay of 25.4 mm (1 in.) to 51 mm (2 in.) at approximately 10 years. Therefore, prior to awarding additional contracts for the 127 mm (5 in.) asphaltic overlay design the county engineer conducted an economic analysis. He found that during the period 1976-77, asphaltic concrete surfacing had increased approximately 10% in cost, which brought his estimate for future 127 mm (5 in.) asphaltic overlays to $68,200/1.6 km (1 mi.). The same estimate showed that a portland cement concrete overlay could be placed over the existing asphaltic concrete for less and at the same time greatly reduce expensive future maintenance; thereby, reducing the annual cost of the highway to the taxpayer. Accordingly, in July of 1977, bids were taken for a portland cement concrete design and award made to the Hallett Construction Co. of Iowa who submitted the low bid of $5.13 per .866 m^2 (1 sq.yd.) or $66,212/1.6 km (1 mi.) for 6.4 km (4 mi.) of 152 mm (6 in.) nominal thickness resurfacing of the existing asphaltic concrete pavement with portland cement concrete.

The existing asphaltic concrete pavement was constructed in 1957 and consisted of a 102 mm (4 in.) thick soil aggregate subbase over which a 115 mm (4.5 in.) thick bituminous-treated aggregate base and a 64 mm (2½ in.) thick bituminous concrete surface had been placed. In general, the existing asphaltic concrete pavement was failing structurally. Its' general condition is shown in Figure 10.

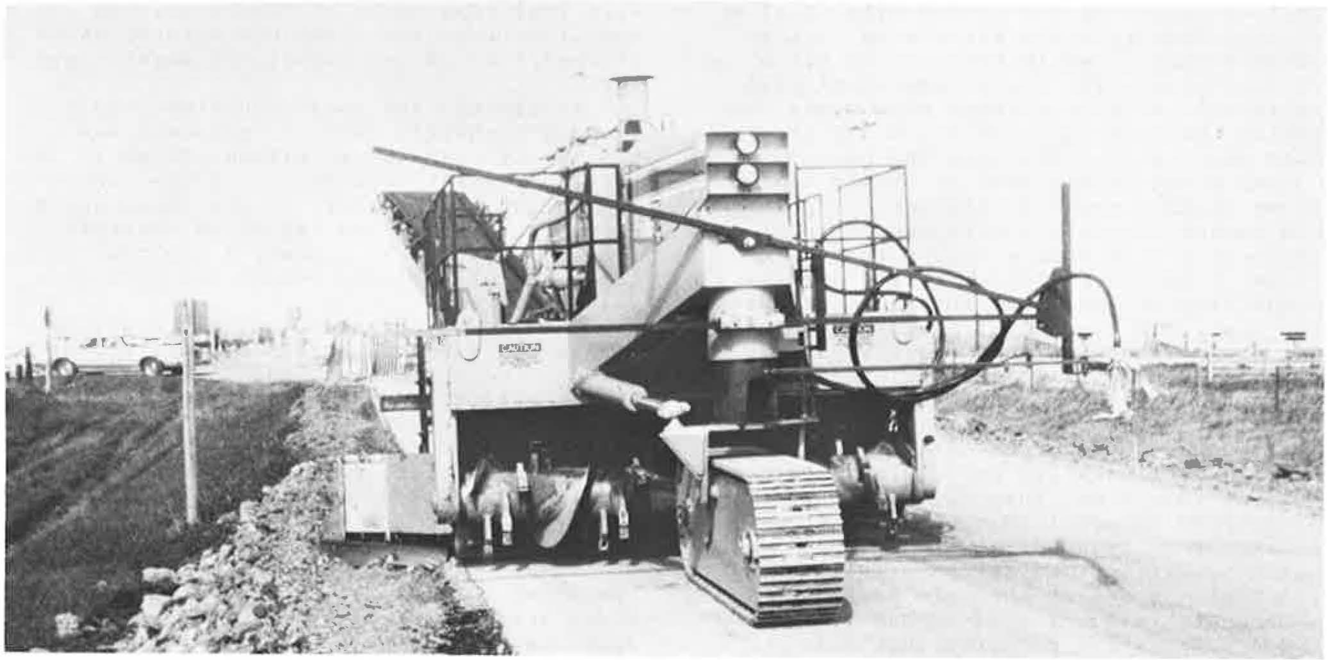
The original pavement had been built 6.7 m (22 ft.) wide and the new portland cement concrete overlay was designed 6.7 m (22 ft.) wide. The crown of the old pavement varied from 76 mm (3 in.) to 115 mm (4.5 in.).

As in-field examination of the old pavement was conducted it became apparent that the profile had deformed less at the centerline than in any other area, and therefore, a decision was made to establish grade control on this project at the centerline of the existing pavement. Specifications required that a nominal thickness of 152 mm (6 in.) and a minimum thickness of 127 mm (5 in.) of portland cement concrete be maintained. In addition, the portland cement concrete overlay would have a maximum 70.4 mm (2-3/4 in.) crown and a minimum 127 mm (5 in.) depth at the centerline. This meant that the greatest thickness of portland cement concrete would occur in the wheel paths of the old pavement; thus, automatically providing greater structural capacity where it was needed the most.

Using the above criteria, the final grade elevation was established with a stringline .6 m (2 ft.) above the existing centerline grade by the contractor. It was then adjusted by the county engineer to remove any obvious discrepancies.

Specifications required that grade for pad-lines for the slip-form paver be electronically established by transferring

Figure 11. Subgrader is transferring the grade from centerline stringline electronically to a cutting bar attached to the wing of the subgrader, which cuts the slip-form paver pad-line at .755 m (2 ft., 5-3/4 in.) below the centerline stringline elevation.

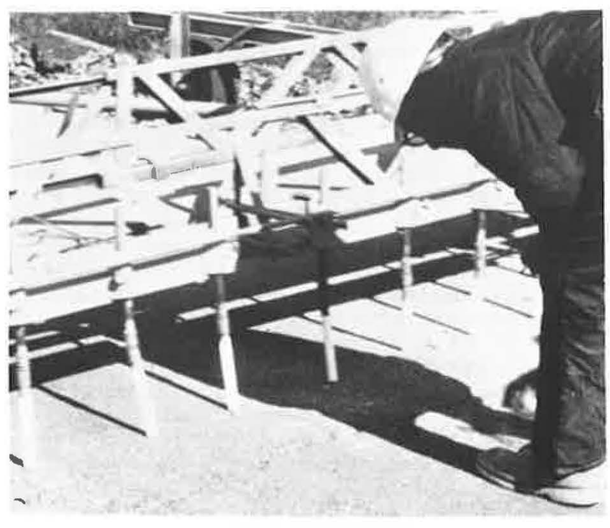


the final profile grade from the centerline stringline to the pad-lines. The contractor accomplished this by use of a half-width CMI sub-grader as shown in Figure 11.

To assure that minimum slab thicknesses as established by specifications were met the contractor constructed a scratch templet, which took its grade from the freshly-cut pad-line. This templet had spring-loaded markers which touched the existing surface at any location where the portland cement concrete would be less in thickness than the minimum required 127 mm (5 in.) depth. Any spot where the templet touched was marked with paint, as shown in Figure 12, and these high spots were then ground to required elevation by the use of a Gallion road grinder.

Concrete for the project was produced in an 6.1 m^3 (8 cu.yd.) central-mix plant on-site. The concrete used met Iowa Department of Transportation B-4 mix requirements and consisted of 233.6 kg (493 lb.) of cement per .765 m^3 (1 cu.yd.) and equal parts of coarse aggregate and sand. Concrete was transported to the site in dump trucks and deposited directly on the old pavement in front of the slip-form paver. Once the concrete was placed in front of the slip-form paver, the remainder of the paving operation was similar to all slip-form projects and the finished pavement was similar to the other portland cement concrete pavements in the County. This project included a bid price for a 152 mm (6 in.) thick nominal slab on a .836 m^2 (sq.yd.) basis and also a .765 m^3 (cu.yd.) bid price based on the

Figure 12. A contractor-constructed spring-loaded templet was used to detect high spots in the pavement surface which would require additional grinding.



theoretical 152 mm (6 in.) nominal thickness.

As in the other projects, the portland cement concrete overlay thickness was constantly checked with a depth probe to assure that minimum thicknesses were obtained. 762 mm (30 in.) long, 13 mm (1/2 in.) diameter deformed bars were placed transverse to the centerline on

0.9 m (3 ft.) centers.

The transverse joints on this project were sawed at different spacing on each mile for the purpose of research. In the first mile, the joints were sawn 12.2 m (40 ft.) apart; in the second mile, 9.14 m (30 ft.) apart; in the third mile, 7.6 m (25 ft.) apart, and in the fourth, 6.1 m (20 ft.) apart. The coarse aggregate used was gravel. On-site surveys made since completion indicate that the 6.1 m (20 ft.) joint spacing is performing the best.

The Boone County project showed that a 152 mm (6 in.) nominal thickness of portland cement concrete overlay could be placed at a cost that was less than a 127 mm (5 in.) asphaltic concrete overlay. In addition to the lower initial construction cost, the history of portland cement concrete pavement on the Secondary System in Iowa indicates a reduced maintenance expenditure per mile as the concrete mileage has increased.

It should further be said that the above projects are all performing excellently at this time. They have all been constructed to specification and meet Iowa Department of Transportation's "Supplemental Specifications for Resurfacing with Portland Cement Concrete Over Asphaltic Concrete Pavement", dated May 10,1977. This specification requires that all portland cement concrete be built with slip-form placing equipment and that the path area over which the slip-form paving machine travels must be constructed to line and grade that provides for placement of the designed thickness of pavement by an electronically-controlled machine. The authors suggest that consideration be given to allowing an alternate method of control, which would allow electronic sensing devices to control slab thickness without construction of pad-lines.

Development of procedures whereby the crown would be allowed to vary could produce a more uniform thickness of slab and should result in material savings. Crown for the new portland cement concrete overlay is specified on the plans and the contractor is required to clean any loose or foreign materials from the existing asphaltic concrete surface prior to the placement of the new portland cement concrete overlay. Where it is necessary to completely remove the existing asphaltic concrete due to poor subgrade support, consideration should be given to thickening the portland cement concrete overlay section through that area. On the Boone County project the portland cement concrete overlay was thickened a uniform 64 mm (2½ in.) through such areas and a sawed transverse joint was placed at the transition point. The simple, but very practical depth probe discussed earlier was used on all projects and assures that the required minimum thickness is obtained.

It is advisable that cut and fill stakes be placed on each side of the roadway at 15.2 m (50 ft.) intervals so that centerline grade can be very simply reestablished if lost. It is required that any subgrade over which the new portland cement concrete overlay will be placed, which is not asphaltic pavement, must be uniformly moistened prior to concrete placement.

All of the portland cement concrete overlays used concrete mixed in accordance with Iowa Department of Transportation specifications for Class B concrete, which allowed full use of locally available aggregates.

In Clinton and Cedar Counties, where the old asphaltic concrete pavement was completely removed, a uniform 152 mm (6 in.) portland cement concrete thickness was required for the overlay. In the three cases -- where the existing asphaltic concrete roadway was used as a base, a nominal thickness of portland cement concrete was specified.

The use of the old asphaltic concrete roadway as a base provides several advantages to the contractor. Bad weather has little effect on construction and paving can start again immediately after an extensive rainfall. In addition, the old asphaltic concrete roadway provided an excellent haul road for materials and a supply route to the slip-form paver. No rutting was encountered ahead of the paver.

In all cases, close control of the amount of water in the portland cement concrete mixes resulted in little or no edge slump to the new portland cement concrete overlay.

The authors feel that the projects reviewed in this paper have developed very practical and usable designs and construction techniques that can be applied in any case where a portland cement concrete overlay is specified over an old asphaltic concrete pavement in order to prolong its life with a minimum of future maintenance.

As additional projects of this type are undertaken, more sophisticated procedures for establishing the grade for the portland cement concrete overlay from the old grade will no doubt be developed. It is suggested that a ski arrangement, which electronically senses grade at the centerline and both edges of the old pavement, be considered.

References

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