Construction of Thin Bonded Concrete Overlay

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In 1981 a bonded concrete overlay 3 in. thick was placed on I-81 north of Syracuse under a contract with the New York State Department of Transportation. I-81 is a six-lane divided Interstate highway that has an annual average daily traffic of 23,000 with 8 percent trucks. The existing concrete pavement was overlaid for a length of 3 miles in all northbound and southbound lanes. Two lanes in each direction were closed to traffic while the overlay was placed. Traffic was maintained on the third lane and a thickened asphalt-concrete shoulder. The concrete overlay was placed to remedy widespread longitudinal and transverse joint deterioration caused by porous coarse aggregate in the existing concrete pavement. The freezing and thawing of water in the coarse aggregate caused a surface spalling problem and layered cracking beneath the surface similar to D-cracking. Deteriorated pavement at the joints was removed to a 3-in. depth by using a milling machine. A nominal 3-in.-thick concrete overlay was bonded to the existing pavement with a cement-sand grout after scarification, sandblasting, and cleaning. The resulting 6-in.-thick lift of concrete at the deteriorated joints was designed to bridge the deterioration and provide a long-lasting overlay. Pavement blowups were occurring on the 23-yr-old existing pavement, which dictated the installation of pressure relief joints before overlaying. The surface preparation and cement-sand grout have resulted in an adequate bond. The thicker concrete overlay is bridging the deterioration. Shrinkage cracking, which developed during paving in hot weather, and reflection cracks over existing pavement cracks have not resulted in performance problems to date. Dust control during surface preparation needs improvement. Pavement friction generally is adequate but needs further study. Overall rideability is excellent.

The original I-81 concrete pavement was constructed by the New York State Department of Transportation (NYSDOT) in 1957 and was part of a contract for 12 miles from North Syracuse to Oneida Lake. A 40-ft-wide grass median separated the three northbound lanes from the three southbound lanes. The concrete pavement was placed 9 in. thick. Steel mesh reinforcement was placed between middepth and 3 in. below the surface of the concrete slab. Lanes were 12 ft wide. Transverse contraction joints were sawcut at 43-ft intervals. Steel dowels 1.25 in. in diameter by 18 in. long at 1-ft intervals provide load transfer at the transverse joints. The driving lane and middle lane were integrally paved 24 ft wide. The longitudinal contraction joint was sawcut, and a 5/8-in.-diameter deformed steel bar was used at 40-in. intervals as a longitudinal joint tie. The median lane was paved 12 ft wide. The longitudinal joint between the median lane and the previously placed lanes consisted of a formed keyway and a two-piece threaded longitudinal joint tie at 40-in. intervals. A bituminous sealer was used for both the longitudinal and transverse joints.

The concrete used in the original construction had a cement factor of 6.2 bags/yd^3 and a water/cement ratio of 0.42 and was air entrained. A range of 3 to 6 percent total air content was specified. The coarse aggregate was a crushed stone graded from 3/8 to 2.5 in. The coarse aggregate was an argillaceous dolomite from a nearby stone quarry.

An attempt was made in 1972 to solve the spalling deterioration, which was occurring at the transverse joints. The entire transverse joint was removed after approximately 2 ft had been sawcut on each side of the joint. A new dowel load-transfer device was installed. Steel dowels were grouted into holes drilled into the existing slabs, new concrete was placed, and the joint was sawcut and sealed. This joint replacement was performed up to the funding limits for the contract. Project engineers found that many additional joints needed treatment at that time.

EXISTING PAVEMENT CONDITION

A pavement evaluation that included pavement coring was performed in 1980. Observation of pavement condition and inspection of full-depth cores confirmed that the coarse aggregate was the cause of the deterioration of this concrete pavement. The deterioration consisted of popouts of the coarse aggregate near the surface and extensive spalling at the longitudinal and transverse joints. The joint spalling was more severe at the pavement edges and at the intersection of the longitudinal and transverse contraction joints. A large number of asphalt patches had to be used to repair the spalls.

The argillaceous dolomite used was highly absorptive. Water that had penetrated from the pavement surface or from the joint faces was trapped in this absorptive stone. During the winter, this water froze and expanded and developed enough internal pressure to cause the surface popouts and the surface spalling.

Cores taken in deteriorated areas at the joints showed horizontal layered cracking for the full 9-in. depth of the core. Only broken pieces were retrieved from cores taken directly over the transverse joints; these cores indicated more deterioration than cores taken farther away from the joint. Cores taken in the center of the slab were intact, consisted of sound concrete, and only showed deterioration at the surface where a surface aggregate popout coincided with the core. The surface where exposed to water and where water could be held and trapped, such as the pavement edges and joint faces, were the places that showed the most deterioration. The spalling was continuous; it started on the outer surfaces and progressed inward as new faces and the porous coarse aggregate were exposed to water and freezing. During construction when pavement edges were visible and pavement sections were removed, the classic hourglass shape of D-cracking deterioration at the pavement joint was observed.

Deterioration was also occurring where the transverse joints had been replaced. After 8 yr, this joint-replacement treatment was found to have separated at the interface between new and existing concrete. Water was entering the pavement through this separation, and spalling deterioration of the original concrete, which contained the porous coarse aggregate, was occurring. This trial construction technique showed that extensive repairs were necessary and a different repair method was needed.

Blowups were another type of deterioration present in the existing pavement. Fines and incompressibles had infiltrated the transverse joints with time. Winter sanding for traction and lack of a durable and maintainable joint sealer had caused this problem. The pavement blowups occur when temperatures are warm; the concrete expands and the filled joints cannot accommodate the expansion. The blowups that had occurred were patched with asphalt concrete after removal of the buckled and shattered concrete.

In some instances the blowup occurred across all three lanes of pavement. Transverse joints closest to the blowup opened wider as a result of the pressure relief afforded by the blowup. At other times, blowups occurred in one or two of the three lanes. When these partial-pavement-width blowups occurred, displacements also occurred in several adjacent transverse joints. The pavement slabs in the affected lanes moved in toward the blowup. The blowup-free lane or lanes remained stationary. Transverse-joint misalignment of as much as 9 in. was noted.

Inspection of cores and observations of the pavement showed a difference in performance in the longitudinal joints. The joint with a formed keyway and two-piece tie was weaker than that with the deformed-bar tie used in integral-lane paving. Corrosion of the two-piece tie weakened its threaded connection. When the blowup occurred, the ties pulled apart and broke or bent. When this occurred, the longitudinal joint was no longer tied together and could separate because of infiltration of fines. Separation had not occurred as yet on this project; some edge support was still being provided by the formed keyway.

A third type of pavement distress was slab cracking. In general, these cracks were located over culverts crossing underneath the pavement. Such cracks were caused by differential movements in freezing temperatures due to the difference between temperature in the soil near the culvert and that further away from the culvert. Usually only a single crack was present, which followed the direction of the culvert underneath. In general, the pavement at the crack was being held together by the steel-mesh reinforcing.

The 3-mile section chosen for rehabilitation has one overhead structure at the southern end of the project near the I-481 interchange. There are two mainline structures, northbound and southbound, over NY-31 2 miles from the project beginning. The mainline structures were also rehabilitated under this contract with a new high-density-concrete bonded wearing course.

DESIGN

Based on favorable experience of other states with a bonded concrete overlay, success in New York State with bonded concrete pavement inlays and bonded high-density-concrete bridge deck overlays, and the need for a longer-lasting solution than an asphalt overlay, a concrete overlay was chosen. Asphalt concrete was assumed to have a 7-yr service life before it became necessary to use another overlay, whereas a concrete overlay was assumed to have a 15-yr life. Comparisons showed that the concrete overlay and the two asphalt overlays were nearly equal in cost. The design chosen was a 3-in.-thick bonded concrete overlay.

To address the deterioration at the longitudinal and transverse joints, the specifications called for milling to a depth of 3 in. to increase the concrete thickness to 6 in. at these distressed locations. The milling depth was determined in advance and planned to stay above the existing steel-dowel load-transfer devices. In this way, the dowels would remain in place, provide load transfer, and not have to be replaced at high cost. Because no faulting had occurred at the transverse joints, it was assumed that enough dowel embedment in solid concrete and dowel strength existed to provide load transfer. Figure 1 shows a cross section of the thickened section.

To relieve the pressures built up in the pavement, which caused the blowups, and to prevent future blowups, asphalt-concrete pressure-relief joints at full pavement depth and full width (three lanes) were specified. The pressure-relief joints were located at blowup locations and at the ends of the northbound and southbound mainline structures over NY-31.

Cracking in the existing pavement was handled by specifying wire mesh in areas of wide cracking where the existing mesh no longer functioned in holding the pavement together. The wire mesh was placed to span the cracks and at the interface between new and old concrete. Cracks were expected to reflect through the new overlay, and the new wire-mesh reinforcement was depended on to hold the cracked pavement tightly together. Faulting had not occurred at these cracks, which indicated that load transfer from aggregate interlock still existed. The alternative to correcting the cracking, which would have been complete slab replacement and installation of control joints at the location of the cracks, was deemed too expensive for the benefit.

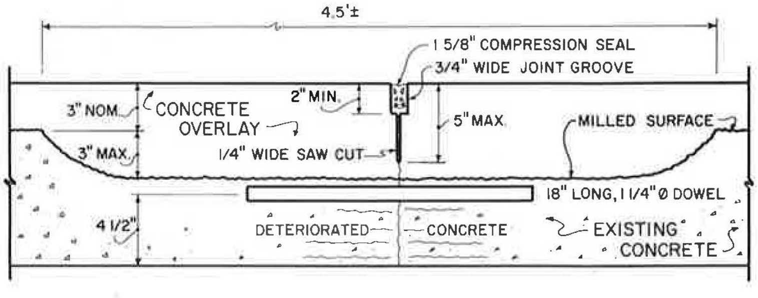
In order to maintain traffic during construction, the following scheme was used. The right-hand, 10-ft-wide shoulder was thickened with a wedge of asphalt concrete. The median and middle lanes were then closed to traffic, and two lanes of traffic were maintained on 10 ft of the driving lane and the 10-ft right-hand shoulder. Traffic was allowed on the new concrete overlay after placement, curing, and joint sealing in the median and middle lanes. The 4-ft-wide median shoulder was brought to the grade of the new concrete overlay by using asphalt concrete. The remaining driving lane was closed to traffic and the remaining lane of concrete overlay constructed. Two lanes of traffic were maintained on a 22-ft-wide portion of the new concrete overlay. The right-hand shoulder was then brought to the new overlay grade by using asphalt concrete.

To prepare the existing concrete surface for overlaying, the following operations were specified. The entire surface was to be scarified by using a milling machine to a depth of 1/4 to 1/2 in. After concrete millings had been swept or vacuumed from the pavement, this same surface was to be thoroughly sandblasted to remove loose chips and contaminants that would interfere with bond.

Milling was specified to be done to a 3-in. depth at transverse and longitudinal joints. The amount of surface distress present was used to estimate the quantity of deep milling.

A cement-sand grout was specified as a bonding medium. The grout specification called for mixing to a thick slurry in a mortar mixer by using 1 part of portland cement to 1 part of concrete sand by

Figure 1. Transverse contraction-joint cross section.



volume. Water was added to achieve the desired fluidity.

The concrete used for the overlay was a modified NYSDOT class D mix. This mix had a cement factor of 725 lb/yd^3, a water/cement ratio of 0.44, and a specified air content of 5.5 to 9.5 percent. The coarse aggregate used in the mix had a maximum size of 1 in.; most stone had a nominal size of 3/8 in. The mix was modified by specifying a water-reducing retarder in all concrete. The water reducer was used for workability at lower slumps and to take advantage of higher strengths due to any water reduction. This class D concrete mix was used in the past as a concrete pavement inlay and bridge deck overlay in thicknesses of 2 to 3 in.

Sealing of the new transverse and longitudinal joints, which were reestablished by transverse saw-cutting over the existing joints, was accomplished by specifying a preformed neoprene compression sealer. Dimensions of the transverse joint sealer are given in Figure 1.

A finished grade 2.75 in. above the original theoretical grade was specified. To achieve the new theoretical grade, the contractor was given the choice of deeper scarification or thicker overlay placement. The clearance of the one overhead structure was adequate and was not affected by the new overlay thickness.

Plans and special specifications were prepared and were advertised for bids. The low bidder of the eight contractors submitting bids was determined on September 4, 1980. The contract was officially awarded on October 14, 1980. Full-scale construction did not begin until the following spring.

CONSTRUCTION

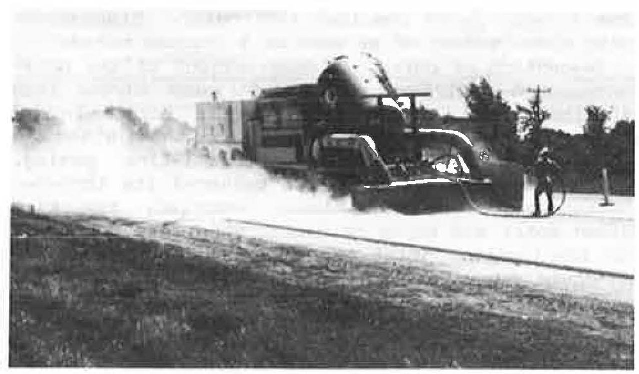
Construction of the concrete overlay began April 6, 1981. Paving and associated work was completed October 31, 1981. Signs, arrow boards, and plastic post delineators were used to route traffic onto the median and middle lanes in both the northbound and southbound directions, limiting traffic to two lanes in each direction. When traffic rerouting was complete, a wedge of asphalt concrete was placed over the existing 10-ft-wide right-hand shoulder. This wedge flattened the cross slope of the shoulder and thickened the existing asphalt concrete. When this asphalt paving was complete, traffic was routed onto two 10-ft lanes made up of the right-hand shoulder and a 10-ft-wide portion of the right-hand driving lane. This left the median and middle lanes free of traffic so that construction could begin.

The following construction sequence was used. Scarification of the entire concrete surface to a depth of 1/4 to 1/2 in. was accomplished by using a large milling machine with a mandrel 78 in. wide. To meet the proposed grade and to remove irregularities, some sections of pavement that were high were milled to approximately an inch in depth. Most millings were picked up by the self-loader during milling and were trucked to a disposal area off the highway. Some of the millings were sold as is by the contractor for use in fills and driveways. A rotary broom mounted on a small tractor swept and windrowed the remaining millings for removal. This operation generated dust, because the sweepings were dry and not picked up and removed. Street sweepers were used to reduce the dust. Although the dust was reduced, the water used created a slurry with the fine millings, which later dried. Additional sandblasting was required to remove the dried slurry.

While the transverse-joint reservoirs were still visible, their locations were marked by using steel pins offset in the shoulders.

Deep milling was performed on transverse joints that emitted a hollow sound when sounded with a chain drag or a hammer. Hollow regions were delineated with paint. Except for a few joints, all emitted a hollow sound. Deep milling generally was ±2 ft on each side of the transverse joint, full lane width, and 3 in. deep. This deep-removal operation did not break up the layered concrete in the lower portion of the slab. The deep milling did expose the upper portion of the steel dowels as the concrete was milled. The exposed dowels were not dislodged and incurred only minor gouging due to the milling operation. No corrective action was necessary.

Figure 2. Pavement sandblasting machine in operation.



Deep milling was also done on the longitudinal joints. A smaller milling machine that had a mandrel 24 in. wide was centered over and milled the longitudinal joint 3 in. deep. Ten percent of the longitudinal joint was in good condition and did not require the deep milling. High pavement mesh that was encountered during milling did not hamper production. The steel wires were broken, pulled out, or flattened in place. Loose wire or exposed ends were later cut off by hand. A vacuum truck and rotary broom were used to remove millings not picked up by a self-loader on the milling machine. The vacuum truck had a specially made high-capacity vacuum capable of picking up fines and stone in an 8-ft-wide pickup. A water spray system for dust control worked well, but continuous adjustments of the water spray and care not to exceed holding capacity were found to be necessary.

The holding capacity of these vacuum trucks had an effect on the dust emissions. Dust emissions increased when the holding tank was more than half full. The single truck on this project was able to maintain production and stay within the limit for capacity.

The milled surface was then sandblasted by using a unique sandblasting machine. This machine was specially made for this type of operation and is the only one in the United States (Figure 2). The sandblaster was mounted on a trailer and consisted of a large air compressor, a vacuum unit, the sand pressure chamber, and four sandblast nozzles mounted in the rear of the trailer. The nozzles were constructed to sweep in arcs while pointing down at the pavement. Skirts, enclosures, and vacuum hoses were used to contain and pick up the sandblasting sand, concrete chips, and dust. In spite of the enclosures and vacuum system, dust did escape to affect nearby homes and adjacent traffic. Continuous efforts resulted in improvements to the operation, but additional improvements are still needed. Sandblasting is necessary for bond and to remove partially loosened concrete chips, contaminants, and the dried slurry that forms when the millings are wetted and then dried.

Milling, sandblasting, and vacuum removal were operations handled by subcontractors. The concrete and asphalt paving and related work were performed by the general contractor.

Pressure-relief joints were installed after milling operations. They consisted of sawcutting out a 7- to 17-ft length of pavement to remove, reshape, and compact the subgrade damaged during removal and then filling and compacting dense-graded asphalt concrete in this opening to the top of the existing pavement. There was a need for pressure relief during sawcutting because the pressure in the pavement caused the circular saw to bind as its sawcut kerf closed behind it. The blade had to be freed by using a jackhammer so that operations could continue. After the blade was freed, a wheel cutter was used for the initial cuts. A 4-in.-wide cut was made across all the lanes to relieve the pressures. Traffic was halted temporarily while cutting took place. Two cuts were made by using the wheel cutter. Sawcuts were then used to provide a neat edge for the pressure-relief joint. When the concrete overlay was placed later, work was not stopped to install these pressure-relief joints; paving was done directly over the asphalt concrete. A strip of the concrete overlay was shoveled out while still plastic to break the continuity of the overlay. The edges were sawcut after the concrete had set, the excess overlay concrete was removed, and the space was filled and compacted with a dense asphalt concrete to the surface of the overlay.

After sandblasting and vacuum removal of any residue, the concrete paving operation began. A portland-cement grout was spread by hand and broomed into the prepared surface. Grout was placed only 10 to 20 ft ahead of the paver to prevent drying of the grout before paving. The grout consisted of equal parts by volume of portland cement and concrete sand. It was mixed in a mortar mixer with enough water to give a flowable, slurrylike consistency. The mortar mixer and cement, sand, and water containers were mounted on a flatbed truck that moved along with the paving operation. Hand placement of the grout was rapid enough to stay ahead of the paver. Estimates by the contractor showed that this operation could handle paving 24 ft wide.

The overlay was slipformed a lane at a time beginning with the median lane. A standard slipform paver with a leveling auger, internal vibrators, and an extrusion screed was used. For the initial placement, grade and alignment for paving were provided by a previously set, taut stringline. In subsequent lane placement, grade was taken from the previously placed lane. Deep-milled areas were paved simultaneously with the overlay. Adjacent traffic was narrowed to one lane during paving because the extra lane was needed to give the paver room to work. It was also used by the transit mix trucks to reach and supply the paver with their chutes. This lane was available only during off-peak traffic hours (Figure 3).

The class D concrete was supplied from an existing concrete batch plant, which was located 17 miles from the project. Depending on traffic, the driving time was about 1/2 hr. Some delays were experienced when the concrete trucks were caught in the traffic delays caused by the project.

After the ingredients had been batched into the trucks, 90 percent of the mix water was added and the concrete was mixed. The concrete was agitated while in transit. When the trucks arrived at the project, water was added and the concrete mixed to achieve the desired 2.5-in. slump. The average slump produced was 2.25 in. The concrete had an average entrained-air content of 7 percent. A set-retarding, water-reducing admixture was used in all the overlay concrete. Compressive strengths of 3,900 psi at 4 days were achieved with this mixture; 28-day compressive strengths were 5,500 psi. Compressive-strength test results were used as a basis to open portions of the concrete overlay to traffic after 4 days. This was necessary at the NY-31 interchange ramps due to the maintenance of the traffic scheme.

Figure 3. Middle-lane grouting and paving adjacent to previously overlaid median lane.

Immediately after paving, the plastic concrete was scored 1/8 in. wide and 1/2 in. deep with a straightedge and an edging tool over the transverse joints. The previously marked joint locations were used. These location pins were necessary because the narrow contraction crack was not visible in the irregular, scarified, milled surface. The scoring was an extra precaution taken by the contractor to ensure correct placement of the contraction crack if sawing delays occurred. This 1/2-in. scoring may not be sufficient to initiate a contraction crack. Sawcutting was not delayed; therefore this shallow scoring was not tested.

Transverse texturing was done with a motor-driven tine rake mounted on the same machine as the white-pigmented curing-compound sprayer. A tine texture of grooves 3/16 in. wide and about 1/16 to 1/8 in. deep at 3/4-in. spacing resulted from this operation. Tining was stopped 2 to 3 in. from the edge that would form a side of the longitudinal joint. This was done to prevent rounding that edge. When adjacent lanes were paved, the concrete was butted against the previously placed lane. No keyway or joint ties were used.

Immediately after texturing, the white-pigmented curing compound was applied at a rate of 75 ft^2/gal. This was twice the normal rate.

Transverse-joint sawing was done as soon as the concrete had hardened sufficiently to allow sawing equipment on it, and sawing could be done without concrete raveling. In most cases this sawing was done within 5 to 6 hr. An initial transverse sawcut was made 5 in. deep at the thicker areas of the joints. This depth of cut was made to ensure formation of a joint at the existing contraction crack. The sealer reservoir was formed by sawcutting after the adjacent lane had been placed.

Preformed neoprene transverse joint sealers were installed after the sawcut joint reservoir faces had been sandblasted clean and a lubricant adhesive applied. A hand-pushed machine was used for compressing and pushing the seal in the slot. The seal was installed after two lanes had been completed.

The remaining 12-ft end of the 36-ft-long seal was coiled and tied. The sealer was stored in the

Table 1. Friction numbers.

Parameter	Northbound Lane Driving	Northbound Lane Middle	Northbound Lane Median	Southbound Lane Driving	Southbound Lane Middle	Southbound Lane Median
No. of tests	15	15	15	14	14	14
Average	31	29	43	29	24	37
Standard deviation	3	3	4	3	2	4
Range	25-37	24-35	32-49	25-33	21-27	30-42

Note: Friction numbers in the table are dynamic coefficient of friction multiplied by 100. The dynamic coefficient of friction was determined by using the locked-wheel test trailer with full-scale ribbed tire according to ASTM E274. Testing was performed at 55 mph on July 12, 1982.

space between the construction work and the traffic. When construction of the third lane had been completed, this remaining end of the seal was installed. Both ends of the seal were wrapped around the edges of the overlay.

In those places where blowups had occurred and had caused transverse-joint misalignment between lanes, a hot poured liquid polyvinyl chloride sealer was used rather than the neoprene, which would have had to be cut at the misalignment intersection. Experience showed that a cut end of neoprene sealer will allow water and fines to infiltrate. The fines will build up and force the sealer from its reservoir where it will be exposed to traffic and be destroyed or torn out. With the loss of the sealer, the entire joint becomes accessible to water, salts, fines, and incompressibles. The liquid sealer was also used to seal the transverse joint constructed over the separated edges of the transverse-joint replacement done under the previous contract.

The longitudinal joints were sealed with a preformed neoprene seal placed in a sawcut reservoir in the same manner as the transverse seals.

The shoulders on either side of the pavement were paved with asphalt concrete to match the new grade of the concrete overlay. The shoulder paving was done while traffic was diverted to complete the construction.

POSTCONSTRUCTION FINDINGS

To determine whether the minimum thickness had been achieved and also to test the bond of the overlay, 4-in.-diameter cores were taken. The cores showed that the desired thickness had been achieved. To determine bond strength, the cores were subjected to a modified shear test. The core was supported on steel rollers 1.5 in. apart. A load was applied vertically through another steel roller centered on the bond interface. It was assumed that flexural effects were minimized. The shear force divided over the specimen's cross-sectional area was reported as its shear strength. Testing on 96 cores showed an average shear strength of 147 psi, a standard deviation of 36 psi, and a range of 45 to 250 psi. The fracture resulting from testing always occurred in the original concrete. The presence of the coarse aggregate affected the shear strength. Coarse, laminated, porous stone in the plane of the fracture resulted in lower strengths. The mortar grout and surface preparation resulted in an adequate bond to the existing concrete.

Additional testing was performed in October 1982 with a shear collar device similar to that used by the state of Iowa. Testing of ten 4-in.-diameter cores, which were approximately 1 yr old, showed an average strength of 575 psi, a standard deviation of 126 psi, and a range of 363 to 808 psi.

The difference in values is due to the differences in test methods. Nevertheless, both methods and visual observations show an adequate bond.

Narrow transverse cracking was noted during construction of the overlay. The cracks are ±0.008 in. wide and extend for the full depth and lane width of the overlay placement. Crack spacing as close as 1.5 ft was noted. In general, most slabs had four to six cracks in the overlay. Cores showed that the cracks formed near the surface while the concrete was still plastic and then progressed and fractured full depth after the concrete had hardened. Observations after construction was completed showed that the cracking predominated in the lanes placed during the hot summer months, whereas the lanes placed in the cooler fall temperatures were nearly crack free. The observations show that high temperatures, normal drying shrinkage, and slab curling due to day and night temperature differentials combined to cause the transverse cracking. Because the cracking is so narrow, no repairs are practical. Pavement in another state had shown similar cracking and had not experienced performance problems. It was therefore decided to monitor the pavement and determine the effect of the cracks on performance.

A detailed preconstruction survey was carried out for future reference on test sections set aside to represent the project. A California-style profilograph was used to measure roughness in the overlaid driving lanes of the two 2,000-ft-long test sections. The results show a profile index (PI) of 14.4 in. in the northbound driving lane and 14.8 in. in the southbound driving lane. A maximum PI of 12 is specified for new concrete pavement construction. These test results are adequate for this type of construction. Paving grade taken from the previously placed lane and the paving delays, which result in starting and stopping the paver, caused the roughness.

The rideability of the completed overlay was measured by using New York's test vehicle. The present rideability index was determined for the length of all three lanes in each direction. The test results show excellent weighted average values for each lane.

Friction testing with New York's locked-wheel pavement friction test trailer was performed at the posted speed of 55 mph. The testing was performed at 0.2-mile intervals throughout the 3-mile length of the project in each of the lanes. Testing took place after 8.5 months of traffic, including one winter.

As can be seen from Table 1, friction numbers lower than expected values were found in the southbound middle lane. The average friction number of 24 was below the expected minimum value of 31 at this test speed. A marginal friction number (29) was also found in the southbound driving lane and the northbound middle lane.

Both median lanes, which had less traffic, show higher friction numbers than the other heavily used lanes. It appears that the initial rough mortar ridges formed when tine texturing was done had worn away and caused this differential between lanes. Observations of the pavement on November 3, 1982, showed a loss of microtexture in the lane between the tine grooves. The median lanes had the coarsest microtexture, whereas the driving and middle lanes 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.

ACKNOWLEDGMENT

I would like to thank Louis Bell, William McCarty, and John Restino of NYSDOT and Jack McCambley of Eastern Rock Products, Inc., for their comments and assistance in writing this paper.

Publication of this paper sponsored by Committee on Rigid Pavement Construction.

Portland-Cement Concrete Inlay Work in Iowa

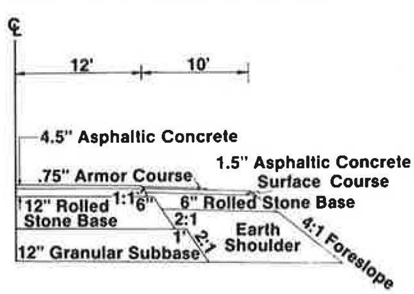
GEORGE CALVERT

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-