FINAL

BONDED, THIN-LIFT, NON-REINFORCED PORTLAND CEMENT CONCRETE RESURFACING
IOWA HIGHWAY RESEARCH BOARD
PROJECT HR-191

DEPARTMENT OF TRANSPORTATION
IOWA

FINAL

REPORT
FOR
IOWA HIGHWAY RESEARCH BOARD

PROJECT HR-191
JUNE, 1980

BONDED, THIN-LIFT, NON-REINFORCED PORTLAND CEMENT CONCRETE RESURFACING

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Final Report

This Final Report contains all of the material that is in the Interim Report (Part 1) covered by pages 1 thru 22 and Appendices A thru G.

Part II contains the Final Report, pages F-1 to F-3.

We have been observing this project closely since the completion of construction in September of 1977. The Iowa Department of Transportation has cooperated in the testing of this section by running the delamtect machine over the project shortly after its completion in October, 1977 and then in the fall of 1978 and the fall of 1979, and then again on April 1 and 2, 1980. Cores were taken at the completion of the job and in April of 1980, 49 cores were taken. Of these, 31 were used to check the bond strength and 18 for the purpose of trying to correlate other types of testing for bond strength with the shear tests used for this project. This is being done as a separate project.

In addition to these tests, the author has observed several other thin lift bonded Portland Cement concrete overlay projects and some of these observations appear in the text of this report.

The objectives and early conclusions are shown on Page ii. All conclusions still seem valid. There has been no failure in the overlay to date. Where lack of bond exists the overlay is still in place. The author believes that if and when these pieces do break off, we will be able to clean up the area with a sandblaster, put grout on the old slab and pour new concrete giving a bonded patch.

Milton L. Johnson P.E.

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ACKNOWLEDGEMENTS

This Research Project was sponsored by the Iowa Highway Research Board and Clayton County in cooperation with the Iowa Concrete Paving Association. Appreciation is extended to the following persons and firms whose efforts and cooperation contributed to the overall success of the project.

The Clayton County Board of Supervisors, whose farsightedness allowed this project to be possible:

Virgil Wessel
Kermit Klinge
Vernon Diers

To all my staff, but to two members in particular:

Glen Meisner, P.E., and Harlan Hedeman

To the Iowa Highway Research Board for voting to contribute $50,000 to the project.

To the following Department of Transportation employees for their concern, cooperation and hard work:

Jerry Bergren, P. C. Engineer
Ralph Britson, Concrete Testing Engineer
Clare Schroeder, Soil Design Engineer
Vernon Marks, Research Engineer
Dutch Stohlmeyer, P. C. Construction Engineer

To the contractor and sub-contractors and their staffs:

Prime Contractor: Fred Carlson Co.
Decorah, Iowa

Scarifying: Cedar Falls Construction Co.
Cedar Falls, Iowa

Sandblasting: Capital Engineering Co.
Minneapolis, Minn.

Waterblasting: Robert White
Cocoa, Florida

And finally to the Iowa Concrete Paving Association and Marlyn Knutson in particular for his work and cooperation in setting up the project, coordinating activities, aiding construction and assisting in the compilation of information on the project.

ABSTRACT AND RESEARCH OBJECTIVES

A Research Project involving two, three, four and five inches of bonded Portland Cement Concrete Overlay on a 1.3 mile Portland Cement Concrete pavement was conducted in Clayton County, Iowa, during September, 1977, centering on the following objectives:

1. Determine the mixing and proportioning procedures required in using a conventional, central mix proportioning plant to produce a dense Portland Cement Concrete mixture using standard mixes with super-water reducing admixtures;
2. Determine the economics, longevity and maintenance performance of a bonded, thin-lift, non-reinforced Portland Cement Concrete resurfacing course using conventional procedures, equipment and concrete paving mixtures both with and without super-water reducing admixtures;
3. Determine if an adequate bond between the existing pavement and an overlay of thin-lift, dense, non-reinforced Portland Cement Concrete can be obtained with only special surface cleaning and no surface removal or grinding.

Conclusions:

1. Normal mixing equipment and proportioning procedures could be used using a conventional central-mix proportioning plant. This was successful when used with super-water reducing admixtures. Only minor changes need be made in procedures and timing
2. The time has been too short since the completion of the project to determine how the new pavement will perform, however, initially it appears that the method is economical and no reason is seen at this time why the life of the pavement should not be comparable to an all new pavement.
3. The initial test results show that bond strength, regardless of which method of cleaning is used, scarifying, sand blasting or water blasting, far exceed what is considered the minimum bond strength of 200 PSI except where the paint stripes were intentionally left, thus showing that the paint must be removed.
4. It appears that either cement and water grout or sand, cement and water grout may be used and still obtain the required bond.

OBJECTIVES SOUGHT AND OBSERVATIONS NOTED

Objective 1.

Determine the feasibility of proportioning, mixing, placing and finishing a thin-lift (approximately two inches) of bonded, dense, non-reinforced P.C.C. using conventional central batch plant with transit mix trucks and slipform paving equipment in resurfacing existing concrete pavements.

Comments:
Objective was achieved. Some problems included uniform mixing and discharging from transit mix trucks. Material was readily placed with slip-form paver. Refinements of proportioning, mixing and delivery are still needed. Uniformity of concrete mixture will most likely alleviate the finishing problems experienced. More knowledge and experience is needed with use of super-water reducing admixture.

Objective 2.

Determine the feasibility of partial depth repair of deteriorated transverse joints in concrete pavements using a bonded, dense, non-reinforced P.C.C.

Comments:
Existing partial depth repairs, with and without resurfacing, exhibited excellent performance to date. Recommend additional research to determine: (1) if partial depth repair is a viable alternate to traditional full-depth repair in different pavement conditions; and, (2) the minimum requirements for concrete mixtures used for partial depth repair.

Objective 3.

Determine if an adequate bond between the existing pavement and an overlay of thin-lift, dense, non-reinforced P.C.C. can be obtained. (Surface scarified with Roto-Mill).

Comments:
Objective achieved to our satisfaction. Delamination testing indicates complete bond attained and still existing to date. Shear testing at the interface indicates very high bond strengths, 1,000 PSI $\pm$ average. Additional research recommended to determine if sufficient and lasting bond can be attained when old surface is cleaned rather than scarified. Additional equipment development is needed to provide for mechanical application of grout.
(See Appendix A.)

Objective 4.

Determine the economics, longevity, and maintenance performance of a bonded, thin-lift non-reinforced P.C.C. resurfacing course as a viable alternate to bituminous resurfacing of concrete pavements.

> *Comments:*
> Concrete paving industry spokesmen indicate competitive initial construction costs are quite possible. Refinements to procedures, equipment, etc., mentioned above as well as a larger-sized project are needed to verify expectations.

Conclusions

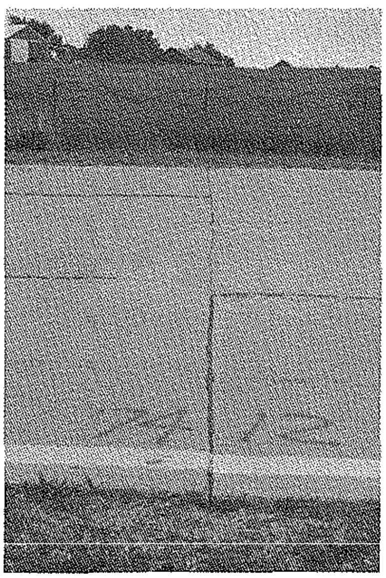
Iowa's first attempt to apply its bridge deck repair and overlay procedures and techniques to pavement resurfacing was successful as verified by the experience and test results of the short Demonstration Project on U. S. Route 20.

Additional research is required to refine the procedures, equipment, techniques, etc., in order to provide designers with a viable alternate to bituminus resurfacing for concrete pavement restoration and rehabilitation.

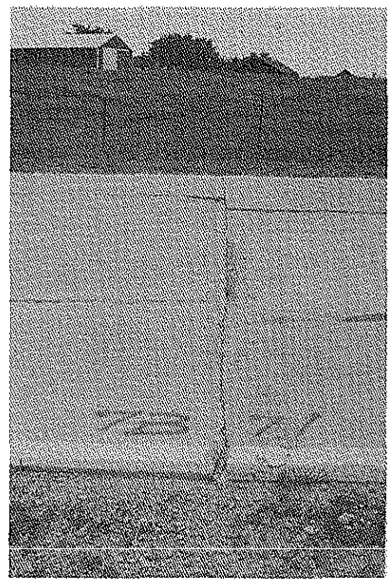
With some basic concerns still in question, the Clayton County Research project was proposed with the objectives as stated in the abstract.

PROJECT LOCATION CRITERIA

Choice of project location was based on essentially five criterion. First, a location that would be conducive to allowing a contractor to employ high production slab preparation, concrete mixing and slip-form paving equipment. Secondly, a location where a contractor did not have to move in a central mix plant special for this project. Thirdly, a location that had steep grades and flat sections. Fourth, there had to be distress in the existing pavement to the extent that maintenance repairs were imminent. Fifth, a study of the improvements in structural integrity by adding two inches, three inches, four inches or five inches of concrete to an existing slab needing strengthening.



Typical Transverse Joint



Typical Random Crack

The project site chosen is located on Secondary Road C-17 in eastern Clayton County, commencing at the town of Clayton and proceeding west and northerly a distance of 1.3 miles. The existing slab is 22 feet wide, six inches thick, standard P. C. Concrete pavement constructed in 1968. Approximately 3500 lineal feet of this project were on a grade of 11 percent.

The original pavement was constructed of crushed limestone coarse aggregate from the Bente (Watson) Quarry at Elkader. The sand came from Essman Island at Guttenberg. There is some random cracking and some of the transverse joints (40 ft. spacing) exhibit faulting in the range of ½ inch+.

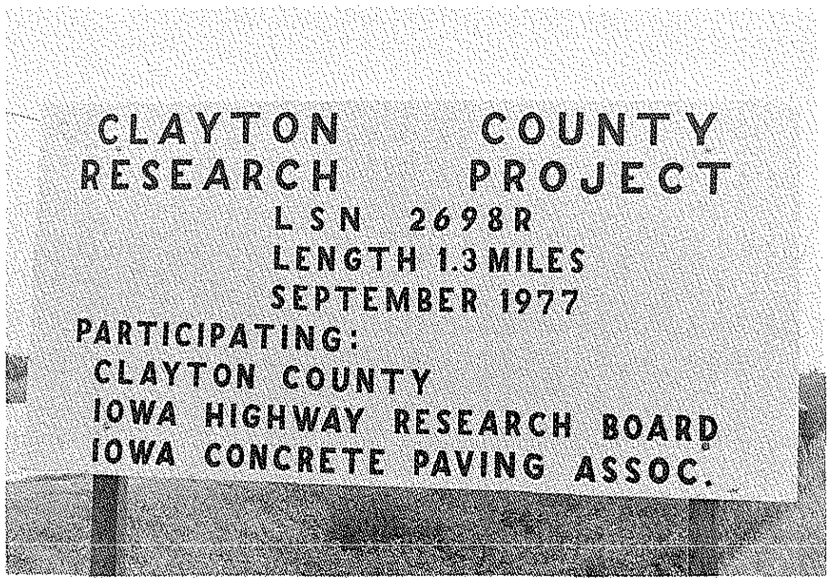
The road carries a large number of trucks to a grain terminal and a silica sand mine in the town of Clayton.

Present traffic on this section of road is as follows:

Average Daily Traffic	651
Average Daily Truck Traffic	280

PROJECT DEVELOPMENT

On April 29, 1977, the Iowa Highway Research Board allocated $50,000 to Clayton County, Iowa for Research Project HR-191 (Clayton Co. LSN-2698-R) at the location previously mentioned. Clayton County allocated an additional $75,000 to finish the project and to construct an additional .396 mile to evaluate sections with greater distress. This allocation included overruns, shoulders, and miscellaneous. These sections were three inches, four inches, and five inches thick, with and without some reinforcing. The project was let in cooperation with the Iowa Concrete Paving Association. On July 12, 1977, a contract was awarded to the Fred Carlson Company of Decorah, Iowa in the amount of $112,520.26.



The contract allowed 20 working days with the completion date of October 7, 1977. All of the work was paid for directly or incidental to 11 contract items. They are as follows:

Item 1. **P.C. Pavement Placing - 17,089 sq. yds.** This item of work included full compensation for furnishing all labor and equipment necessary to place, finish, texture, saw, seal, and cure the concrete, including the materials and placement of the grout, in accordance with the plans and specifications.

Item 2. **P. C. Concrete C-4 WR - 626 cu. yds.** This item of work included the following mix proportions:

Coarse Aggregate	1508 lbs./cu. yds.
Fine Aggregate	1508 lbs./cu. yds.
Cement	595 lbs./cu. yds.
Water	291 lbs./cu. yds.

An approved water reducer was used as approved by the Office of Materials, Highway Division, Iowa Department of Transportation. The method of measurement was cubic yards, using a count of batches incorporated. The cubic yard price was full compensation for furnishing all raw materials and for proportioning, mixing, and delivery of concrete to the paving machine, including quantities to be used for full and partial depth repairs.

Item 3. **P. C. Concrete C-4 SWR - 533 cu. yds.** This item of work included the following mix proportions:

Coarse Aggregate	1536 lbs./cu. yds.
Fine Aggregate	1536 lbs./cu. yds.
Cement	626 lbs./cu. yds.
Water	225 lbs./cu. yds.

The following super water reducer dosage rates were approved by the Office of Materials of the Iowa Department of Transportation for this research project:

Manufacturer	**Rate**
Sikament	24 fl. oz. per 100 lbs. cement
Mighty 150	14.5 fl. oz. per sack of cement
Melment	35-40 oz. per 100 lbs. of cement
Fx-34 (Dry)	3/4 lb. per sack of cement

The method of measurement for the C-4 SWR mix, which included the super water reducer, was cubic yards, using a count of batches incorporated. The cubic yard price was full compensation for furnishing all raw materials, proportioning, mixing and delivery of concrete to the paving machine, including quantities to be used for full and partial depth repairs.

Item 4. **Surface Preparation - Scarify 3201 sq. yds.** This item of work included the removal of the top ¼ inch of the existing pavement and placing any material removed on the shoulders adjacent to the overlay. This item also included vacuuming or airblasting the slab to assure a clean slab.

Item 5. **Surface Preparation - Special Scarify 65 sq. yds.** This item of work included the trimming of faulted joints over ¼ inch and scarifying an area 1¼ inch deep to match up to existing slab at the end of the project.

Item 6. **Surface Preparation - Sandblast 8389 sq. yds.** This item of work included sandblasting the entire surface and airblasting to remove all loose particles from the surface.

Item 7. **Surface Preparation - Waterblast 6110 sq. yds.** This item of work included waterblasting the entire surface.

Item 8. **Partial Depth Patch Repair - 86 sq. yds.** This item of work included scarifying partial depth repair areas and stockpiling the removed concrete.

Item 9. **Steel Reinforcing - 962 lbs.** This item of work included furnishing No. 4 reinforcing bars, 12 foot long, and placing at 30-inch centers staggered.

Item 10. **Chain Link Fabric - 233 sq. yds.** This item of work included furnishing zinc-coated chain link fabric and placing.

Item 11. **Full Depth Patch Repair - 50 sq. yds.** This item included the removal and disposal of old pavement.

PROJECT DESIGN

The total length of the project was 1.30 miles. Division I was 0.396 mile financed by Clayton County. Division II was 0.904 mile with the Iowa Highway Research Board participating in the amount of $50,000 and the remaining $28,000 being paid for by Clayton County.

A breakdown of contract items for each division is listed in Appendix E. Scarifying, sandblasting and waterblasting were used for surface preparation.

A conventional C-4 WR mix was used for the concrete for half of each division. The other half of each division was placed with a modified C-4 mix with super water reducers added (C-4SWR). Also, Reinforcing bars were used in three areas with one being in each of the three inch, four inch and five inch thick sections.

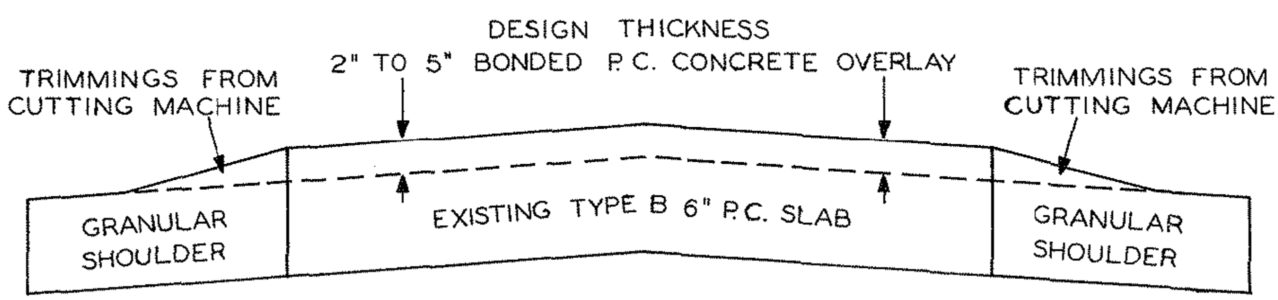
In Division I, the thickness ranged from two to five inches. All transverse joints were sawed except for 100 lineal feet. Three hundred (300) lineal feet of the centerline joint were sawed. Reinforcing steel of 100 feet per section was used in the three inch, four inch and five inch thick sections. The reinforcing steel consisted of No. 4 bars, 12 foot long, staggered at 30-inch centers.

Zinc-coated chain link fence was designed for 100 lineal feet in three-inch section.

In Division II, the thickness design was a nominal two inches. Transverse joints were sawed except for 400 lineal feet. No centerline joint was sawed.

All sections were designed to try many different variables, but still to allow the contractor to achieve maximum production.

A TYPICAL SECTION



P.C. BONDED OVERLAY
CLAYTON COUNTY

MIX DESIGN

The concrete mix objective was to design a conventional mix with normal water reducers and a mix with super water reducing agents which could be mixed in a central mix plant and delivered in agitor or dump trucks to the paving site. The mix should have the workability to be placed with a conventional slip-form paving machine.

It was decided by the Iowa Department of Transportation engineers that the high strength of 850 to 1270 PSI concrete in flexure, achieved in the U. S. #20 Research Project, was not necessary from a design standpoint. **However, it was unknown if the lower water-cement ratio gave us the excellent bond strengths achieved on that project.** It was DOT C-4 with water reducer (C-4 WR) and a mix which included a super water reducer (C-4 SWR). The water-cement ratios of the above mixes are detailed in Appendix D.

These two mixes enabled evaluation and comparison to be made of the bond strength between C-4WR and C-4SWR mixes and the existing slab.

A decision was made to try six trial batches of the C-4 SWR on a construction project on U. S. #52 for intersection approach slabs. Two different brands of super water reducing agents were tried, Sikament and Mighty 150. The reason for the trial run was to observe the mixing with a central mix plant, hauling in trucks with and without agitation and the workable time limit for each mix. Although the workability by hand was more difficult than conventional concrete, it gave the contractor a feel for what water-cement ratio he could effectively slipform and what water-cement ratio would be required for handwork. These tests verified a water-cement ratio of 0.33 with the Sikament and 0.36 with the Mighty 150. This information was very beneficial to the contractor prior to slipforming the 11 percent grade on the Clayton hill.

PROJECT CONSTRUCTION

The contractor, the Fred Carlson Company, constructed the project in conjunction with a large paving project on U. S. #52. The sequence of construction items follows:

PADLINE:

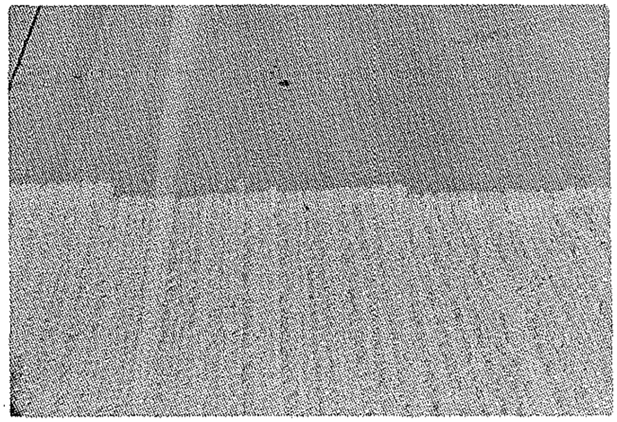
The contractor elected to build a padline for the slipform paving equipment by utilizing the existing rock shoulder. The padline was trimmed flush with the existing slab with a motor patrol. The excess material that remained on the slab was broomed off prior to any surface preparation.

SCARIFICATION:

The surface scarification was sublet to the Cedar Falls Construction Company of Cedar Falls, Iowa. The 3229 square yards of scarification of the existing slab were done with a Galion RP-30 Road Planer which has a 30-inch cutting head. The total time to scarify 3229 square yards, and 75 square yards of partial depth repair, and cut of faulted joints was 20 hours. The end runout to tie into the existing pavement surface was accomplished by additional removal of 1¼ inch depth to provide a flush header.

As per plan, 27 transverse joints received partial depth repair, 13 joints were repaired full width, and 14 joints were repaired one-half pavement width. Depths of repair varied with the amount of deterioration. The average depth was three inches. The Galion machine was also used to trim all faulted joints over ¼ inch.

Galion RP-30 Road Planer



Portion of Scarified Surface

Partial Depth Joint Scarification

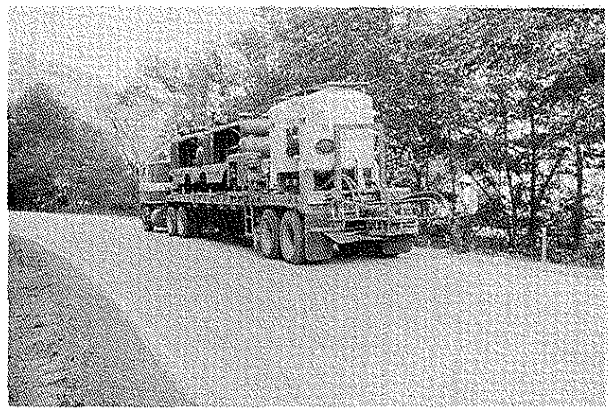
SANDBLASTING

The 8688 square yards of sandblasting were done using a mobile sandblaster manufactured by Capital Engineering Company, a subsidiary of Oster & Pederson, Inc. of Minneapolis, Minnesota.

The trailer-mounted blasting unit consists of two 600 cfm Chicago pneumatic compressors, two 5-ton canned sand units, a Ford six-cylinder industrial engine driving a Vickers 29 gpm hydraulic pump, and a hydraulic drive system for the rear wheels of the trailer. An International Transtar is used to haul the equipment to the job site.

Sandblasting is a one-man operation. Four switches on the panel control the sand to four #7 nozzles fed by 1¼ inch hose and suspended from a metal frame which is mounted on the rear of the trailer. The frame automatically oscillates and the frequency of the oscillation can be controlled from a dial on the control panel. Blasting with 110 psi of nozzle pressure, the four #7 nozzles can cover about 10 square yards per minute. The width of coverage can be varied from 9 to 16 feet and the forward speed from 0 to 14 feet per minute.

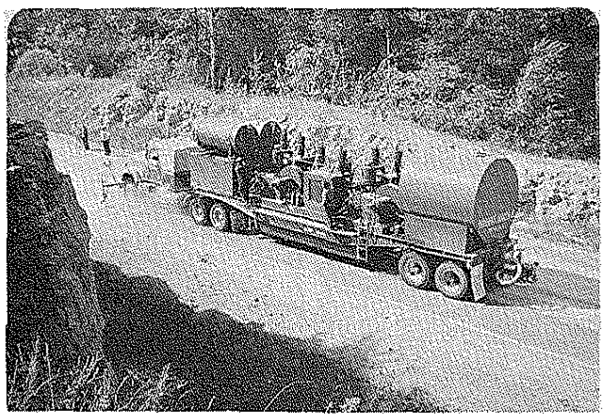
Side View Sandblaster



Rear View Sandblaster

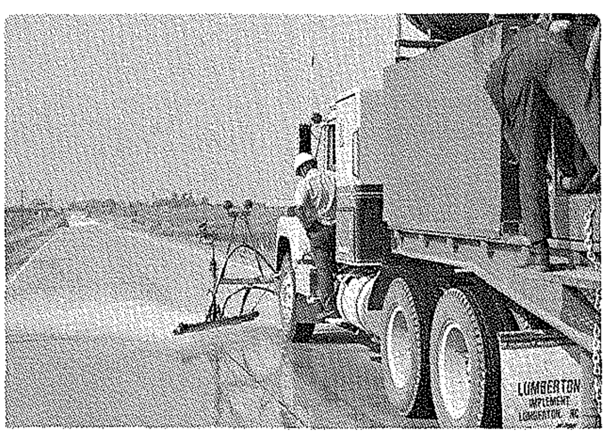
WATERBLASTING:

The 6110 square yards of waterblasting were sublet to Robert White of Cocoa, Florida. For this project he used a Transtar Eagle with a 400 hp Cummins diesel engine and secondary low-speed gear box. The waterblaster carried 8000 gallons of water and weighed 142,000 lbs. when loaded. Three 6-53 diesel-powered pumps gave 480 hp delivery. One hundred (100) gallons of water per minute were pumped at 6000 lbs. per square inch through 30 stainless steel fan nozzles of .04 diameter. The pumps are capable of 10,000 lbs. per square inch at less gallons per minute. The height of the nozzles from the pavement averaged four inches. The approximate rate of travel was two miles per hour on the level portions of the project. On the Steep grades speeds varied up to approximately 7 miles per hour.



Waterblaster

Front View Waterblaster



Side View Waterblaster

Portion of Waterblasted Surface

PAINT STRIPE REMOVAL:

The centerline and edgeline paint stripes proved somewhat troublesome to remove. The scarifier, of course, handled its section nicely. The sandblaster was able to remove the paint by a double shot of sandblasting but the waterblaster was unable to effectively remove the paint.

A special tip was put in the waterblast spray bar and the pressure increased from 6000 to 10,000 PSI. However, this spray nozzle only cleaned a stripe approximately one inch wide. Equipment is available to introduce sand into the water spray which probably would take care of this problem.

In the sections which were cleaned by waterblasting, most of the paint stripes were removed either by scarifying or sandblasting. The paint remaining after the waterblasting between Stations 284+00 to Station 288+00 and from Station 297+00 to 298+00 and 314+00 to 315+00, were left in place in order to check the bond over existing paint.

CONCRETE MIXING & HAULING:

The concrete was mixed in a Model S Rex central mix plant. Six or seven cubic yards were mixed per batch. The concrete was hauled in dump trucks and agitors without agitation.

The mixing time used for the C-4 WR mix was 60 seconds. The haul distance was 11.5 miles. The average time from mixing to dumping was 28 minutes in Div. II. The reason for the length of time was that the truckers had to back down 4000 lineal feet of an 11 percent grade. The average time of haul in Division I was 19 minutes. The average loss of slump was two inches and the average loss of air was 1.8 percent from plant to the paving site.

The initial mixing time was set at two minutes for the super water-reducer mixes. An attempt to reduce this mixing time in fifteen second increments was unsuccessful. The first batch appeared to be alright with a one minute, forty-five second mixing time, but it was observed that the next two were not sufficiently mixed, therefore, the mixing time was returned to two minutes for the remainder of the job.

The Sikament mixture was used from Sta. 286+00 to Sta. 306+00 in Div. II. The average time of haul was 19 minutes. The water-cement ratio first used was 0.34 and after 78 cubic yards it was changed to 0.35. The average loss of slump was 1½ inches and the average loss of air was 1.6 percent from the plant to the paving site.

The Mighty 150 was used from Sta. 262+11 to 273+50 in Div. I. The average time of haul was 18 minutes. The water-cement ratio first used was 0.36 and after 12 cubic yards it was changed to 0.37. The average loss of slump was 1⅝ inch and the average loss of air was 1.3 percent from the plant to the paving site.

Both super water reducers were pumped from drums into a calibrated 17-gallon holding tank located about two feet above the drum intake of the mixer. The holding tank had a 1¼ inch inside diameter sight tube. In each six yards there were 7.2 gallons of Sikament used or 4.5 gallons of Mighty 150 used. Approximately 20 gallons of water was used to flush the pump, lines, tank, and two-inch dispensing tube between products and at the end of the days' operations.

The plant was set up to dispense the air entraining agent at the beginning of the batching sequence. The complete batching sequence took from 15 to 18 seconds. After seven to eight seconds of aggregate feeding, the super water reducer was dispensed in the aggregate which carried it into the mixing drum.

In this mixing operation, it appeared that after the air entraining agent and some water was dispensed, all other materials went in at once. The admixture companies agree that the concentrated water reducer should not come in contact with the air entraining or the cement. It was observed that after all aggregate had been introduced some cement and water was still being fed into the hopper.

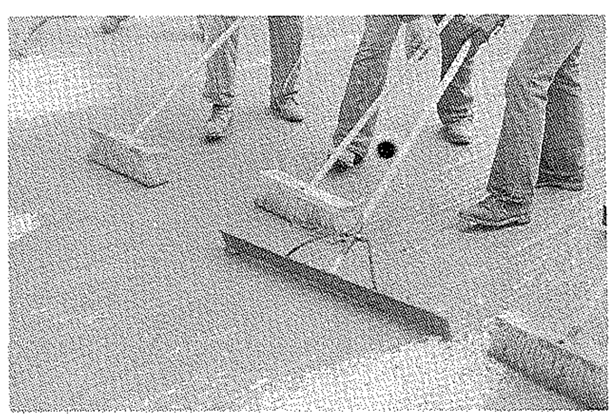
Rex Model S Central Mix Plant

Loading Agitor Truck

GROUTING:

The first three loads of bonding grout were mixed and hauled in transit mix trucks. The grout consisted of 1376 lbs. of cement and 1410 lbs. of sand (allowing three percent for moisture) and 7½ gallons of water per sack of cement. The first five loads using a

Applying Grout



Applying Grout

transit mix truck were retained 3 hrs. 50 min., 5 hrs. 25 min., 2 hrs., 2 hrs. 55 min., and 2 hrs. 10 min. before being completely unloaded. The reason the grout was in the trucks this length of time for the first two loads, were problems encountered with the paving operation explained under the paving section. (These areas are documented.) Because of the long haul and possible delays in the paving operation, the contractor could only haul and apply one cubic yard of grout to be within the specification limit of 90 minutes.

The contractor elected to mix the grout in his central mix plant in two cubic yard batches and transport to the paving site in agitor trucks. This proved to be a satisfactory method of mixing and hauling the grout.

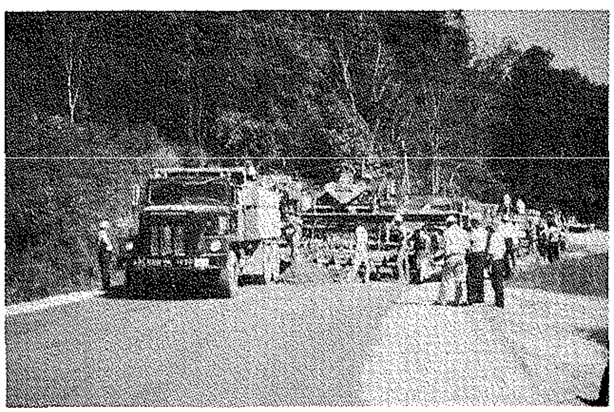
In the last 475 feet of the project, a cement-water grout was used. This consisted of a mix of 1376 lbs. of cement and 853 lbs. of water. This was tried in the event a spray application can be manufactured for applying the grout.

The grout was spread by six laborers using brooms and squeegees.

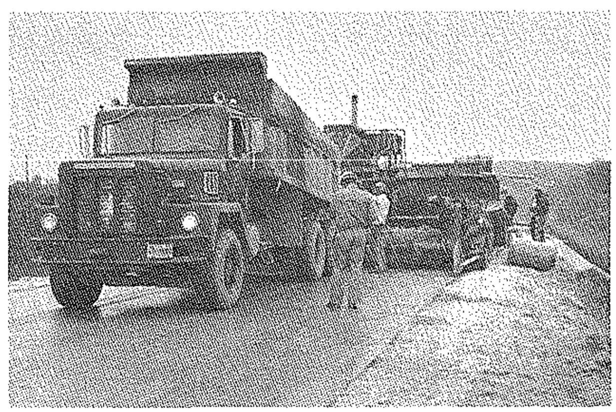
The area covered by the grout varied with the different types of surface preparation. The area covered varied from 550 to 1050 with an average of 750 square yards per cubic yard of grout.

PAVING:

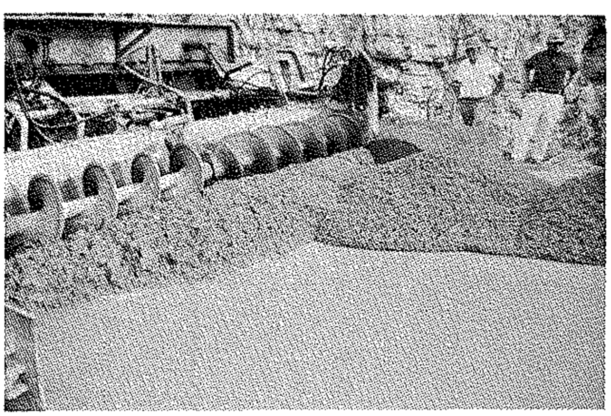
The shoulder width on this project was four feet. This made it necessary for the contractor to drive the loaded concrete trucks on the clean slab. There was evidence of



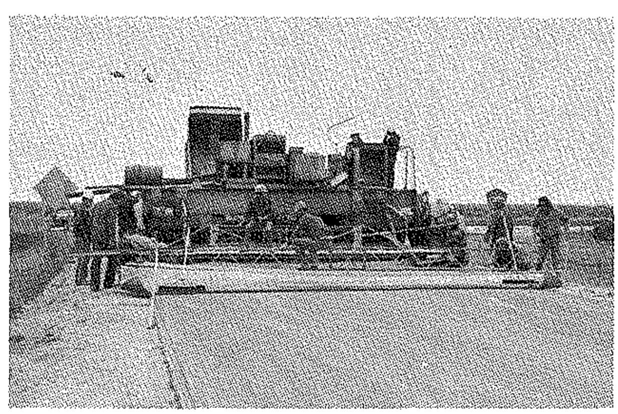
Paving Operation



Dump Truck Hauling Unit



Front View Rex STR Slip-form Paver



Rear View Rex STR Slip-form Paver

oil drippings on the slab, although hand-sandblasting was done prior to grouting but it was difficult to remove all the oil drippings.

A Rex, Model STR, slip-form paver was used for the overlay. It was set for two-inch, three-inch, four-inch and five-inch pavement thicknesses and operated on a graded padline constructed on the shoulders. The paver was equipped with internal tube vibrators as well as pan vibrators. There were also tamping bars in front of the extrusion meter.

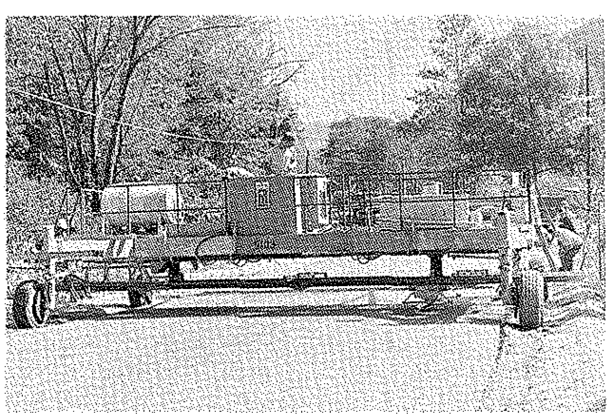
The concrete was discharged from agitors and dump trucks in front of the paver and spread with an auger on the paver. The first 500 feet of paving proved troublesome until adjustments were made on the pan of the slip-form paver and corrections were made to prevent the paver from hanging up on the existing slab. In the first 500 feet, an attempt was made to use less than a ½ inch slump in the C-4 WR mix. Due to the steep grade, this proved troublesome and a 1 to 1½ inch slump worked to satisfaction.

In the section using super water reducers, a water-cement ratio of 0.34 with Sikament was first used. This was increased to 0.35 which gave a good uniform mix. The finishers were not used in this section except to fix up a slight crease when the paver had to stop.

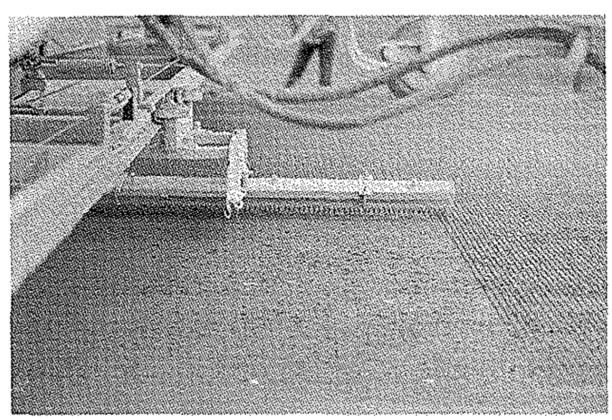
The Mighty 150 worked well with a water-cement ratio of 0.37 for machine finish. The water-cement ratio for Mighty 150 was higher than Sikament but the finishing characteristics seem better. Hand finishing with super water reducing agents with either of the above water-cement ratios was difficult. This was due to the artificial slump effective for approximately 45 minutes. If this life could be extended by retarders, it would be beneficial for handwork.

TEXTURING:

The plastic concrete was textured with a longitudinal Astro-Grass drag and followed by transverse grooving with a CMI-TC-280 texture and cure machine. The texturing bar was changed in the section using C-4 SWR because of the density of the concrete. Shorter tines gave better penetration of the dense concrete and provided the surface texture desired. When using C-4 SWR mix, it is necessary to keep the texturing operation closer to the paver.



CMI-TC-280 Texturing Machine

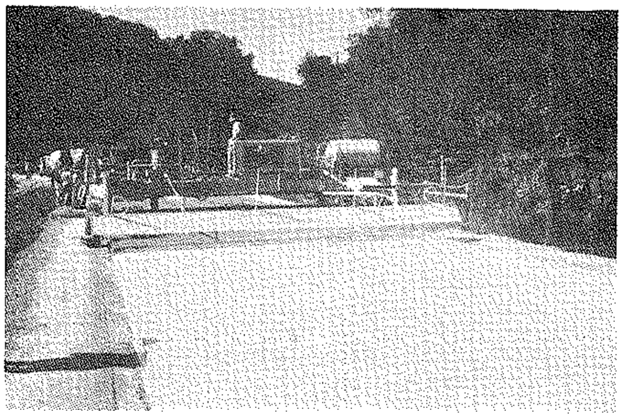


Tine Texture

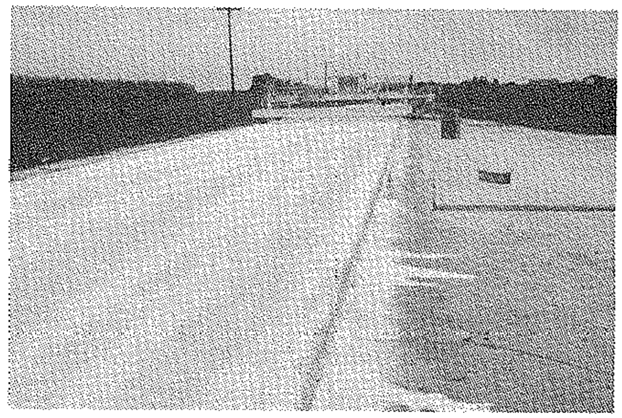
CURING:

A white-pigmented liquid membrane curing compound was used on the entire project. The specified application rate was 0.13 gallon per square yard, which is twice the minimum rate specified for concrete paving in Iowa. This was accomplished by spraying the slab with a normal application immediately after texturing and applying the remaining coat about half an hour later. The full double application was not applied in one application, since it would run off the slab.

From Sta. 301+11 to Sta. 289+53 an application of 0.10 gallon per square yard was used in one application without much runoff of the cure. (This was also done because of anticipated rain.)



CMI-TC-280 Curing Machine

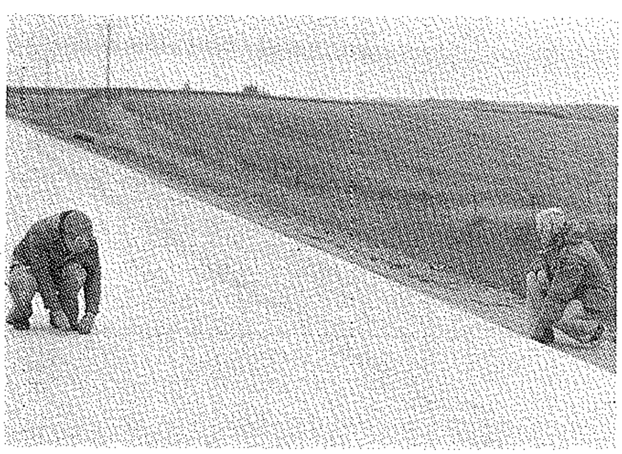


Evidence of Excess Cure

JOINTS:

Nails were driven into the shoulder along each side of the pavement at each transverse joint prior to overlaying so that the joints could be located for sawing and evaluation. The joints were sawed one inch deep except in the three, four, and five inch where 1½ inch deep joints were sawed. Only 300 lineal feet of centerline joint were sawed.

The saw cut was marked by setting nails at predetermined distances in the shoulder measured from centerline.



Measuring Offset for Centerline Joint Saw Cut

Sawing Transverse Joint

REINFORCED SECTIONS

REINFORCING BARS:

Three sections, each 100 feet long using number four reinforcing bars, 12 foot in length, were placed on thirty inch centers staggered from each side of the pavement. These sections were as follows:

Three-inch section - Sta. 265+00 to 266+00
Four-inch section - Sta. 278+00 to 279+00
Five-inch section - Sta. 273+50 to 274+50.

The sections selected for this experiment were areas where the concrete was broken up to the point where normally full depth patching would be used. The attempt is being made in this area to see whether or not some reinforcing and additional depth will be sufficient to carry the traffic or if full depth patching will be necessary in this type of area.

In the three-inch section, the reinforcing bars caught in the paver because the 12-foot length of the straight bars, placed on a parabolic crown, caused the ends to be quite near the surface and the bars appeared to vibrate up to the surface and catch in the pan of the slip-form paver. This problem was not as severe in the 4 and 5 inch sections.

CHAIN LINK FENCE:

The chain link fence experiment proved unsatisfactory. The original thought was that the fence would roll out flat due to the nature of its construction and result in ease of placement. However, when the trucks backed over the fence it curled and when the paver went over the top, vibration carried the fence to the surface and it caught in the pan. After placing 50 lineal feet of the original 100 feet planned, the experiment was scrapped and much of the fabric already placed had to be cut out because it was protruding through the surface.

OBSERVATIONS AND RECOMMENDATIONS:

The following observations and recommendations are offered by the author of this report and include remarks by several persons involved in this project.

Pad Line:

The pad line was difficult to build to the proper profile because the motorgrader operator had worked from the existing slab. In areas of slight settlement in the pavement, the pad line reflected the settlement. An attempt to build this up had limited success. It is recommended a surface ski sensoring system be developed so the paving machine can be controlled from a relatively long section of slab. This will improve the riding qualities of the completed overlay.

Surface Preparation — Scarification:

The advantage of scarification is that it removes any high spots and equalize faulting as well as the top portion of concrete having oil drippings, chloride and other long-term contaminate penetrations. The Galion planer on this project was versatile, maneuverable and efficient in small areas. Larger machines, such as the CMI Roto Mill, offer higher production in large areas of scarification. The author sees no reason to scarify faulted joints below the surface of the lower of the two slabs.

Sandblasting:

Sandblasting equipment on this project had a capability and capacity of adequately cleaning the slab and removing paint stripes. Major problem with sandbalsting was dust; perhaps a hood arrangement to recapture sand and dust before it escapes might correct this problem.

Waterblasting:

Waterblasting equipment adequately prepared the surface but failed to remove paint stripes satisfactorily. If this equipment is to be used on future projects it will require redesigning to produce greater pressures or inject sand. Otherwise, an auxiliary piece of equipment will be needed to remove the paint stripes. It appears this method is probably the most economical and consideration should be given to using two pieces of equipment until sand injection has proven itself.

Grouting:

Bond strength using a sand-cement water grout averaged 654 PSI based on two tests and the cement-water grout averaged 600 PSI. This comparison was between identical surface preparation of sandblasting and super-water reducers.

Some grout was in ready-mix trucks up to 5 hours before use. At that point, there was no visible problem with the grout. However, bond strength of the cores showed a decrease where the grout was used after three hours in the truck.

Grout was spread with brooms and squeegees. In the areas cleaned by sandblasting or waterblasting, squeegees removed nearly all grout from the surface. Brooming, on the other hand, satisfactorily spread the grout and left some on the surface for bond. New mechanical methods are needed to apply grout for better control in rates of application and time and distance ahead of the concrete placement.

There was no visible difference between a ready-mixed grout and central-mixed grout hauled in agitator trucks. The author detects no change in bond strength due to these procedures and either method seems satisfactory.

Concrete Mixing and Hauling:

There were no problems in mixing or transporting concrete. Slump and air loss were minimal with the super-water reducing mix. A two minute mixing time provided a satisfactory mix. An attempt to reduce mixing time to one minute and forty-five seconds did not provide satisfactory mixing. Because of the project layout and many variables needing evaluation, mixing time was returned to two minutes so results could be determined on surface preparation mix design and other factors incorporated in the project.

Concrete Placement:

Actual placing of concrete had few problems. One problem was that the paver did not always have sufficient traction to push concrete up the 11 percent grade. The machine had to be pulled on several occasions. Where the pad line was firm and the quantity of concrete ahead of the machine was not too great, there was no problem. On flatter grades, there was no problem with machine traction. On the curves and transitions, the depth of concrete required close attention so that the transition was consistant with the resurfacing course and the original paving to avoid thin or thick spots. At the direction of the author, depth of paving was kept at a minimum of two inches on Division II and at a minimum of three, four and five as designed in Division I. This accounts for the overrun on the concrete quantities. A resurfacing project designed with a minimum thickness should be computed from one-quarter to one-half inch of overrun to allow for variations in the existing slab. Cleaning equipment also must be kept readily available for oil spills, dirt tracking on the pavement from batch trucks and other contaminants that might effect bond.

Texturing:

To produce the desired results, the texturing machine had to texture concrete that contained super-water reducer a little sooner than expected. This caused minor amounts of pulling and breaking of the edge where the tines came off the slab. However, when the concrete was a little firmer, the tines would not penetrate and provide desired texture. The decision was made to texture early rather than to preserve the edge.

Curing:

The increased application rate of curing compound had to be applied in two applications to keep it from running off the slab. The original design called for twice the normal IDOT rate of cure because of the uncertainty on the amount needed with the type of texturing being done and the thin sections.

Reinforcing:

Areas of reinforcing on this project were not necessarily designed as a practical method but to determine whether reinforcing would add sufficient strength to concrete to eliminate the necessity of making full depth patching over badly distressed areas. If the performance proves to be acceptable, the reinforcing methods developed on continuous reinforced concrete pavements, mesh with built-in charis, or other proven methods should be used.

Joints:

Pulling a string line into the existing saw cut and placing a nail on either shoulder so a string could be drawn on the finished slab to determine position of saw cut was satisfactory. To date, only two cracks have been observed in the surface that are not at saw cuts.

The centerline cut made on a small portion of this project was unsatisfactory. The saw cut apparently did not wind up immediately over the existing centerline. It produced a crack in a portion approximately one inch from the saw cut. The author believes centerline sawing is not only unnecessary but probably detrimental because parallel cracks appeared adjacent to the saw cut.

Bond Strengths:

Preliminary research indicates a bond strength of 200 PSI or higher will provide adequate bond between old and new concrete. It further appears that when this bond is obtained it will endure. This project indicates the following average bond strengths in shear:

- Waterblast C-4 WR Mix, 582 psi based on 8 cores
- Sandblast C-4 WR Mix, 547 psi based on 7 cores
- Scarify C-4 WR Mix, 454 psi based on 7 cores
- Waterblast C-4 SWR Mix, 533 psi based on 7 cores
- Sandblast C-4 SWR Mix, 632 psi based on 10 cores
- Scarify C-4 SWR Mix, 419 psi based on 5 cores

Bond strengths over centerline and edge paint stripes indicated an average bond strength of 113 psi based on six tests.

Shear strengths taken in the old concrete surface and new concrete overlay indicates the following shear strength data:

- Old Concrete Slab, 811 psi (one test)
- New Concrete C-4 WR Mix, 811 psi (one test)
- New Concrete C-4 SWR (Sika), 891 psi (one test)
- New Concrete C-4 SWR (Mighty), 978 psi (one test)

(See Appendix A & B)

FUTURE RESEARCH AND DEVELOPMENT

The author suggests further research and equipment development in the following areas:

1. Research is required on the amount of time that grout may be kept in a mixed condition before it looses effective strength for bonding. On this project, weather conditions were near ideal for concrete work.
2. More information is needed on the effect of high temperatures with bonded overlays to determine if super-water reducers help prevent curling when temperatures are high and winds are such that the surface tends to dry out quickly.
3. If the water blast method is going to be used for slab cleaning, an economical method is required for paint removal.
4. Research is needed in the areas of curing compound quantities on grooves and textured concrete so sufficient quantities can be used without waste.
5. There is concern on the need for pressure relief joints in bonded overlays to prevent blowups. More information is needed in this area to determine if such joints are needed more in overlays than in normal pavements and if needed, how frequently.
6. Research is needed to determine if it is necessary to have a dry pavement before the grout is applied.

CLAYTON COUNTY LSN-2698-R

BOND STRENGTH BY SURFACE PREPARATION

C-4WR mixes contain Plastocrete 161
C-4SWR mixes contain Super Water Reducers

SANDBLAST

Core No.	Station	Overlay Thickness	Grout Type	Shear p.s.i.	Tensile p.s.i.	Admix	Remarks
2	264+25	4"	Cement Only	696		C-4SWR Mighty	Wire Mesh
3	267+50	3 3/4"	Cement & Sand	811		"	Normal
4	269+00	3 3/8"	"	497		"	"
7	277+00	4 1/4"	"	378		C-4WR	"
8	281+00	4 1/8"	"	732		"	"
12	288+50	2 3/8"	"	485		C-4SWR Sika	"
13	289+75	2 7/8"	"	636		"	"
14	293+00	2 1/4"	"	569		"	"
26	41+59	3"	"		373	C-4WR	Joint Corner
27	43+00	2 1/8"	"	386		"	5 hr. grout
35	43+00	2 3/4"	"	310		"	5 hr. grout
36	41+59	2 7/8"	"	887		"	Joint corner
48	292+00	2 5/8"	"	756		C-4SWR Sika	Normal
49	290+00	3 3/8"	"	544		"	At stop sign
52	276+00	4 3/8"	"	457		C-4WR	Normal
54	268+50	3"	"	625		C-4SWR Mighty	"
55	264+50	4"	"	704		"	Steel Mesh
				592		AVE. 16 tests Shear	
					373	AVE. 1 test Tensile	

Appendix A

CLAYTON COUNTY LSN-2698-R
BOND STRENGTH BY SURFACE PREPARATION

SCARIFICATION

Core No.	Station	Overlay Thickness	Grout Type	Shear p.s.i.	Admix	Remarks
1	262+75	2 1/2"	cement only	505	C-4SWR Mighty	Bias shear plane
5	272+75	4 3/4"	cement & sand	449	"	Normal
6	273+25	5 1/8"	"	386	C-4WR	"
15	294+00	2 1/2"	"	398	C-4SWR Sika	"
16	296+00	2 3/8"	"	386	"	"
29	47+75	2 1/2 - 3"	"	366	C-4WR	"
30	49+60	4"	"	593	"	3 1/2 hr. grout
31	51+75	4 1/2"	"	557	"	Normal
32	51+75	4 3/4"	"	386	"	3 3/4 hr. grout
33	49+60	4 1/2"	"	537	"	Normal
47	295+00	2 1/2"	"	358	C-4SWR Sika	"
51	278+00	4 1/4"	"	354	C-4WR	"
53	273+00	5 1/4"	"	183	C-4SWR Mighty	"
				420	AVE. of 13 cores	

WATERBLAST

Core No.	Station	Overlay Thickness	Grout Type	Shear p.s.i.	Admix	Remarks
9	284+25	2 1/8"	cement & sand	553	C-4WR	Normal
10	286+00	2 1/2"	"	513	"	"
11	287+75	2"	"	517	C-4SWR Sika	"
18	297+50	1 5/8"	"	819	"	CL Flat on one edge
19	299+90	2"	"	621	"	Normal
20	304+35	2 3/8"	"	661	"	"
21	307+00	3"	"	537	C-4WR	"
22	310+96	2 1/2"	"	839	"	"
23	312+96	3 1/8"	"	732	"	"
40	310+96	2 1/2"	"	597	"	Corner
41	307+00	3 1/8"	"	282	"	"
42	304+35	2 1/4-2 1/2"	"	354	C-4SWR Sika	Sandblasted over lane marking
43	303+60	2 3/8"	"	406	"	Normal
44	299+90	2 1/4"	"	354	"	"
				559	AVE.	

Appendix A

LSN-2698-R
CLAYTON COUNTY
BOND STRENGTH BY MIX DESIGN

C-4WR (PLASTOCRETE 161)

Core No.	Station	Surface Preparation	Shear P.S.I.
6	273+25	Scarification	386
7	277+00	Sandblast	378
8	281+00	"	732
9	284+25	Waterblast	553
10	286+00	"	513
21	307+00	"	537
22	310+96	"	839
23	312+96	"	732
27	43+00	Sandblast	386
28	46+83	"	290
35	43+00	"	310
36	41+59	"	887
52	276+00	"	457
39	312+96	Waterblast	601
40	310+96	"	597
41	307+00	"	282
29	47+75	Scarification	366
30	49+60	"	593
31	51+75	"	557
32	51+75	"	386
33	49+60	"	537
51	278+00	"	354
		AVE.	512

C-4WR	Scarification	Ave.	454
C-4WR	Sandblast	Ave.	491
C-4WR	Waterblast	Ave.	582

C-4SWR (MIGHTY 150)

Core No.	Station	Surface Preparation	Shear P.S.I.
1	262+75	Scarification	505
2	272+75	"	449
53	273+00	"	183
2	264+25	Sandblast	696
3	267+50	"	811
54	268+50	"	625
55	264+50	"	704
		AVE.	568

LSN-2698-R
CLAYTON COUNTY
BOND STRENGTH BY MIX DESIGN

C-4SWR (SIKAMENT)

Core No.	Station	Surface Preparation	Shear P.S.I.
12	288+50	Sandblast	485
13	289+75	"	636
14	293+00	"	569
48	292+00	"	756
49	290+00	"	544
15	294+00	Scarification	398
16	296+00	"	386
47	295+00	"	358
11	287+75	Waterblast	517
18	297+50	Waterblast	819
19	299+90	"	621
20	304+35	"	661
		AVG.	562

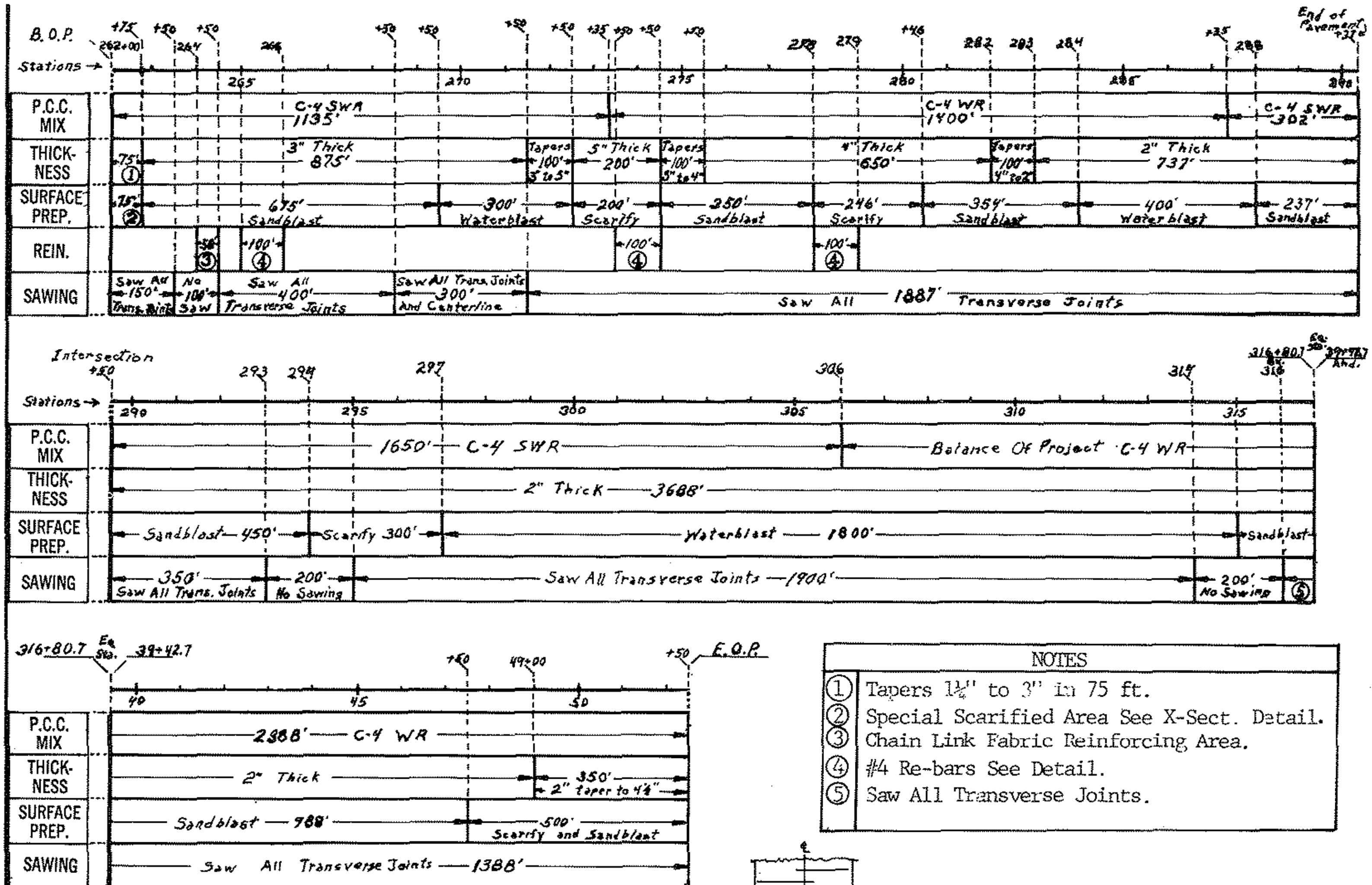
GROUT
(Cement only)

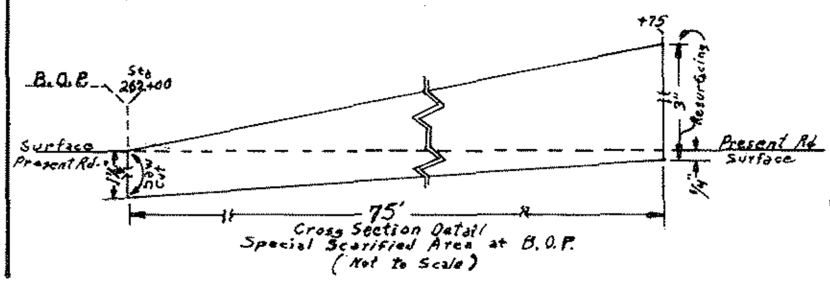
Core No.	Shear P.S.I.	Surface Preparation
1	505	Scarification
2	696	Sandblasting

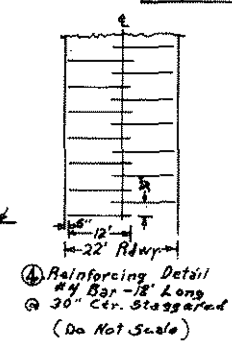
Only two cores were drilled from cement-only grout sections and these represented both scarification and sandblasting. In both instances the results were comparable to cement-sand grout sections.

TENSILE STRENGTH

Core No.	Station	Surface Preparation	Tensile P.S.I.
26	41+59	Sandblast	373
45	297+50	Waterblast	Broke in handling







NOTES

① Tapers 1¼" to 3" in 75 ft.
② Special Scarified Area See X-Sect. Detail.
③ Chain Link Fabric Reinforcing Area.
④ #4 Re-bars See Detail.
⑤ Saw All Transverse Joints.

P.C.C. BONDED OVERLAY
CLAYTON COUNTY, IOWA
RESEARCH PROJECT NO. LSN-2698-R

BEAM BREAKS FOR CLAYTON RESEARCH
PROJECT NO. LSN-2698-R 1977

Beam No.	Mix No.	W/C	Age	Slump	Air	Mod. Rupture	Loc. Break	SWR Brand
1A	C-4WR	0.41	28 Hr.	5/8"	5.8	440	1/4"	----
1A	C-4WR	0.41	47 Hr.	5/8"	5.8	585	3/8"	----
2A	C-4WR	0.42	70 Hr.	1"	7.7	584	1/2"	----
2A	C-4WR	0.42	7 Day	1"	7.7	877	1"	----
3A	C-4WR	0.43	7 Day	7/8"	7.1	759	1 1/8"	----
4A	C-4WR	0.44	7 Day	7/8"	7.4	707	1/4"	----
4A	C-4WR	0.44	14 Day	7/8"	7.4	800	1 1/8"	----
5A	C-4WR	0.44	7 Day	-----	---	832	7/8"	----
6A	C-4SWR	0.34	7 Day	1 3/8"	7.2	849	3/8"	SIKA
7A	C-4SWR	0.355	7 Day	2"	7.1	838	5/8"	SIKA
7A	C-4SWR	0.355	14 Day	2"	7.1	907	1 1/4"	SIKA
1B	C-4SWR	0.35	6 Day	6 1/2"	12.0	638	1/4"	SIKA
2B	C-4SWR	0.35	6 Day	1"	6.7	815	5/8"	SIKA
3B	C-4SWR	0.357	6 Day	2 1/4"	6.8	813	1 1/8"	SIKA
4B	C-4SWR	0.355	1 Day	2"	7.2	195	1/2"	SIKA
4B	C-4SWR	0.355	2 Day	2"	7.2	590	1/4"	SIKA
1C	C-4SWR	0.35	2 Day	3/8"	6.4	510	3/8"	SIKA
2C	C-4SWR	0.33	3 Day	1 1/8"	7.1	804	1/4"	SIKA
2C	C-4SWR	0.33	7 Day	1 1/8"	7.1	913	3/8"	SIKA
3C	C-4WR	0.43	4 Day	1 5/8"	8.2	558	1/2"	----
4C	C-4WR	0.43	7 Day	1 1/4"	8.6	661	5/8"	----
5C	C-4SWR	0.37	4 Day	1 1/8"	6.9	821	1 1/4"	MIGHTY
6C	C-4SWR	0.37	7 Day	7/8"	7.0	808	1/4"	MIGHTY
6C	C-4SWR	0.37	14 Day	7/8"	7.0	947	3/8"	MIGHTY

BEAM BREAKS FOR CLAYTON RESEARCH
PROJECT NO. LSN-2698-R 1977

Beam No.	Mix No.	W/C	Age	Slump	Air	Mod. Rupture	Loc. Break	SWR Brand
7C	C-4SWR	0.37	7 Day	1 3/8"	6.9	841	1/2"	MIGHTY
7C	C-4SWR	0.37	14 Day	1 3/8"	6.9	925	1/8"	MIGHTY
1D	C-4SWR	0.387	2 Day	2 3/4"	7.0	578	1/8"	MIGHTY
1D	C-4SWR	0.387	7 Day	2 3/4"	7.0	834	1"	MIGHTY
2D	C-4SWR	0.38	3 Day	2 1/2"	7.0	641	1/8"	MIGHTY
2D	C-4SWR	0.38	14 Day	2 1/2"	7.0	859	1/4"	MIGHTY
3D	C-4SWR	0.38	2 Day	-----	---	590	3/8"	MIGHTY
3D	C-45SWR	0.38	14 Day	-----	---	854	1 1/2"	MIGHTY
4D	C-4WR	0.43	3 Day	1 7/8"	7.3	535	1/4"	MIGHTY
4D	C-4WR	0.43	6 Day	1 7/8"	7.3	721	1/8"	MIGHTY

COST AND QUANTITIES

NO.	ITEM	UNIT PRICE	DIVISION I QUANTITIES PLAN	DIVISION I QUANTITIES ACTUAL	DIVISION I ACTUAL COST	DIVISION II QUANTITIES PLAN	DIVISION II QUANTITIES ACTUAL	DIVISION II ACTUAL COST	TOTAL COST
1	P.C.Pavt. - Placement Only	$ 3.34 S.Y.	5105.5	5131.9	$17140.55	11984.1	11984.1	$40026.89	$57167.44
2	P.C.Conc. - C-4WR	23.80 C.Y.	261.41	280	6664.00	365.04	541	12875.80	19539.80
3	P.C.Conc. - C-4SWR	29.40 C.Y.	248.58	282	8290.80	283.43	358.5	10539.90	18830.70
4	Surface Prep. Scarify	2.50 S.Y.	1246.4	1273.8	3184.50	1955.2	1955.2	4888.00	8072.50
5	Surface Prep. Sp. Scarify	3.50 S.Y.	36.0	30.0	105.00	29.0	22.0	77.00	182.00
6	Surface Prep. Sandblast	1.00 S.Y.	3125.9	3125.9	3125.90	5263.1	5562.1	5562.10	8688.00
7	Surface Prep. Water Blast	0.50 S.Y.	733.2	733.2	366.60	5376.8	5376.8	2688.40	3055.00
8	Partial Depth Patch Prep.	15.00 S.Y.	---	---	---	86.0	75.0	1125.00	1125.00
9	Steel, Reinforcing	0.40 Lbs.	962.0	962.0	384.80	---	---	---	384.80
10	Chain Link Fence	4.40 S.Y.	233.0	116.5	512.60	---	---	---	512.60
11	Full Depth Patch Prep.	50.00 S.Y.	25.0	---	---	25.0	---	---	---
	TOTALS				$39774.75			$77783.09	$117557.84

Appendix E

Appendix F

* Corrected Report

Form 958
3-74

Conc. Compression
B. Brown
R. Britson
J. Bergren
LSN-2698-R
Clayton

IOWA STATE HIGHWAY COMMISSION
Materials Department

Concrete Compression

Project LSN-2698-R Contract No. County Clayton Lab. No. ACC7-731-734

Producer Carlson Constr. Co. Plant Jobsite Contractor Carlson Constr. Co.

Unit of Material Cement - Dundee; F.Agg. - Kuhlman AAS7-455; C.Agg. - Kuhlman AAC7-450-451;
Sikament SWR; Mighty 150-SWR

Sampled by Britson Date Received 9-12-77 Date Reported 10-5-77

Lab. Number	Sdrs. Number	Date Made	Date To Test	Prop. No.	% Air Content	Slump	W/C	Description	Tested Date	Tested Age	Total Load	Lb/Sq. In.
ACC7-731	Sika-1	1977 9-7	1977 10-5		7.0	3"	.33		1977 10-5	Days 28	136,000	8550
732	2	"	"		"	"	"		"	"	132,000	8300
↓*											AVG	8425
733	Mighty 150 3	1977 9-7	1977 10-5		7.0	3"	.36		1977 10-5	Days 28	124,000	7800
734	4	"	"		"	"	"		"	"	126,000	7920
											AVG	7860

Trial Mixes for Clayton County Overlay Project, LSN-2698-R. Specimens made on Carlson's U.S. 52 Project. Mix are Mixes designed for Clayton County. 3 mixes using Sikament & 3 mixes using Mighty 150. The specimens reported here are from the mix which appeared to be the mix which would be used for Clayton County. The only difference in each of the 3 mixes is the water content.

Sikament - 24 fl.oz. per 100 lb. cement
Mighty 150 - 14.5 fl.oz. per sack cement

Signed Bernard C. Brown

Specification 810
Supersedes 796

IOWA DEPARTMENT OF TRANSPORTATION
Ames, Iowa

Supplemental Specification
for

PORTLAND CEMENT CONCRETE RESURFACING
July 12, 1977

THE STANDARD SPECIFICATIONS, SERIES OF 1972, ARE AMENDED BY THE FOLLOWING ADDITIONS. THESE ARE SUPPLEMENTAL SPECIFICATIONS AND SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

810.01 DESCRIPTION. Resurfacing of concrete pavements shall consist of cleaning and preparation of the existing surface, overlaying with new concrete, and other necessary work as shown on the plans or as specified. The work shall be done according to the Standard Specifications and this specification. Unless otherwise provided on the plans, resurfacing shall accomplish a raise of the existing roadway surface and shall cover the entire pavement surface.

810.02 MATERIALS. All materials shall meet the requirements for the respective items in Part IV of the Standard Specifications, with the following exceptions:

A. Cement. Article 4101 shall apply. The use of Type III (high early strength) cement will not be permitted.

B. Aggregate. Sections 4110 and 4115 shall apply except that the coarse aggregate shall meet gradation requirements of Classification 67 and shall be of a Class 2 durability.

C. Concrete. Concrete for resurfacing shall be Mix No. C-4WR as specified in 2301.04C (See revision in Specification 802), or Mix No. C-4SWR with a super water-reducing admixture, as designated on the plans.

Basic Absolute Volumes per Unit Volume of Concrete:

	Mix C-4WR	Mix C-4SWR
Coarse Aggregate	0.337731	0.343955
Fine Aggregate	.337731	.343955
Air	.06	.060000
Water	.152125	.133760
Cement	.112414	.118330

Approximate Quantities of Materials Per Cubic Yard of Concrete:

Coarse Aggregate	1,508 lb.	1,536 lb.
Fine Aggregate	1,508 lb.	1,536 lb.
Cement	595 lb.	626 lb.
Water	291 lb.	225 lb.
Water-Cement ratio (Design)	0.431 lb./lb.	0.36 lb./lb.
Water-Cement ratio (Maximum)	.489 lb./lb.	0.40 lb./lb.

These quantities are based on the following assumptions:

Specific gravity of cement	3.14
Specific gravity of coarse and fine aggregate	2.65
Weight of one cu. ft. of water	62.4 lbs.

For Mix No. C-4SWR, a super water-reducing admixture shall be used. This admixture, and the dosage rate, shall be approved by the Office of Materials. Currently approved admixtures and their dosage rates are shown on the plans or the proposal.

The slump, measured in accordance with AASHTO T 119, shall be a maximum of 2½ inches.

The intended air entrainment of the finished concrete is 6 percent, but the air content of fresh, unvibrated concrete at the time of placement, as determined by AASHTO T 152, shall be 6.5 percent, with a maximum variation of plus or minus 1.5 percent.

D. Grout for bonding new concrete to previously placed concrete shall consist of equal parts by weight of portland cement and concrete sand, mixed with sufficient water to form a stiff slurry. The consistency of this slurry shall be such that it can be applied with a stiff brush or broom to the old concrete in a thin, even coating that will not run or puddle in low spots. The grout shall be agitated prior to and during its use. The cement to water contact time of the grout shall not exceed ninety (90) minutes before it is placed.

An equivalent grout of portland cement and water, applied by pressure spray, may be substituted with approval of the engineer; however, the intention is to allow this substitution only in a limited area and as a trial.

810.03 EQUIPMENT. Equipment used shall be subject to approval of the engineer and shall comply with the following:

A. Surface Preparation Equipment shall be of the following types:

1. Sawing Equipment shall be capable of sawing concrete to the specified depth.
2. Sand-Blasting and Water-Blasting Equipment shall be capable of removing rust, oil, and concrete laitance from the existing surface of the pavement.
3. Scarifying Equipment shall be a power-operated, mechanical scarifier capable of uniformly scarifying or removing the old surface to depths required in a satisfactory manner. Other types of removal devices may be used if their operation is suitable and if they can be demonstrated to the satisfaction of the engineer.

B. Proportioning and Mixing Equipment shall meet requirements of 2001.20 and 2001.21. Sufficient mixing capacity or mixers shall be provided to permit the intended pour to be placed without interruption.

C. Placing and Finishing Equipment. An approved machine meeting requirements of 2301.07B shall be used. The machine shall be inspected and approved before work is started on each project.

810.04 PREPARATION OF SURFACE. The entire, existing concrete pavement surface shall be uniformly cleaned with sand blasting or water blasting, or shall be scarified, as designated on the plans. The sand blast or water blast shall be of such an extent to remove all dirt, oil, and other foreign material, as well as any unsound concrete or laitance from the surface and edges against which new concrete is to be placed. Where scarification is designated, the existing surface shall be scarified to a depth of 1/4 inch. At transverse joints where the faulting is in excess of 1/4 inch, the high part of the joint will be removed.

Partial-depth repair of transverse joints shall be performed at locations shown on the plans, or as directed by the engineer. The deteriorated concrete shall be removed to a nominal width and depth as indicated on the plans, normally to sound concrete. After the partial depth removal, the area shall be cleaned as described above.

Prior to applying grout in preparation for placement of new concrete, the entire surface shall be cleaned with an air blast.

It is not intended or desired that the existing concrete, prepared for resurfacing, be pre-saturated before grout and new concrete are placed. The prepared surface shall be dry to allow some absorption of the grout.

810.05 PROPORTIONING AND MIXING OF CONCRETE MATERIALS. The applicable provisions of 2301.16 shall apply with the following exceptions and additional provisions:

A. The super water-reducing admixture for improved workability shall be mixed and incorporated in the concrete mixture in accordance with the manufacturer's recommendations and the engineer's instructions.

810.06 PLACING AND FINISHING CONCRETE. The contractor shall take every reasonable precaution to secure a smooth-riding surface. Prior to placement operations, he shall review his equipment, procedures, personnel, and previous results with the engineer, and the inspection procedures will be reviewed to assure coordination. Precaution shall include the following:

Assurance that concrete can be produced and placed within the specified limits, continuously and with uniformity.

After finishing, the contractor shall check the surface with a 10-foot, light straightedge; causes for irregularities exceeding 1/8 inch should be eliminated, and corrections should be made, if practical.

The thickness of all new concrete above the prepared surface shall be as specified on the plans.

Transverse and longitudinal joints of previously placed surface course shall be sawn to straight and vertical edges before surface course is placed adjacent to such joints.

After the surface has been cleaned and immediately before placing concrete, a thin coating of bonding grout shall be scrubbed into the dry, prepared surface. Care shall be exercised to insure that all parts receive a thorough, even coating and that no excess grout is permitted to collect in pockets. The rate of progress in applying grout shall be limited so that the grout does not become dry before it is covered with new concrete.

If required, reinforcement shall be placed as shown on the plans.

Placement of the concrete shall be a continuous operation throughout the pour, including patch areas. Internal, hand vibration will be required at full-depth patches and may be required at partial-depth repairs. Hand finishing with a wood float may be required for producing a tight, uniform surface.

When a tight, uniform surface has been achieved, the surface shall be textured and transversely grooved in accordance with 2301.19 (revised in Specification 802).

After the surface has been grooved, the surface shall be cured in accordance with 2301.22A, except that liquid curing compounds shall be applied at twice the minimum specified rate.

Unless specified otherwise, joints in the resurfacing will be sawn over the existing transverse joints to a depth of one (1) inch and sealed according to 2301.30.

810.07 LIMITATIONS OF OPERATIONS. If traffic is to be maintained during the construction period of this contract, it will be noted on the plans. The contractor shall provide such traffic controls as required by the plans and specifications.

No traffic shall be permitted on the finished resurfacing course until 72 hours after placement if Mix No. C-4SWR is used. When Mix No. C-4WR is used, no traffic shall be allowed on the resurfacing course for seven (7) days after placement. At temperatures below 55 degrees F., the engineer may require a longer waiting time.

No concrete shall be placed when the air or pavement temperature is below 40 degrees F.

810.08 METHOD OF MEASUREMENT. The quantity of the various items of work involved in the construction of portland cement concrete resurfacing will be measured by the engineer in accordance with the following provisions:

A. Portland Cement Concrete Resurfacing. The amount of resurfacing concrete of the mix proportions and admixture specified shall be measured in cubic yards, using a count of batches incorporated.

The area of portland cement concrete pavement, placement only, will be computed in square yards from surface measure longitudinally and the nominal plan width.

B. Surface Preparation. The amount of pavement prepared in accordance with the specifications will be measured in square yards from surface measure for each type of preparation specified. When a special preparation is required, it will be measured as shown on the plans.

C. Partial-Depth Repair. The areas of partial-depth repair of transverse joints will be computed in square yards from measurements of the repair locations.

D. Full-Depth Patches. Patches involving full-depth removal of old pavement and its replacement with portland cement concrete will be computed in square yards from measurements of the areas of concrete removed, except that each patch which is less than 18 square feet in area will be counted as 2.0 square yards.

E. Reinforcing Steel will be measured in accordance with 2404.09.

810.09 BASIS OF PAYMENT. For the performance of acceptable work, measured as provided above, the contractor will be paid the contract unit price in accordance with the following provisions:

A. Portland Cement Concrete Resurfacing. For the number of cubic yards of portland cement concrete resurfacing incorporated, payment will be at the contract price per cubic yard. This shall be full compensation for furnishing all raw materials, and for the proportioning, mixing, and delivery of concrete to the paving machine, including quantities to be used for full-depth patches and partial-depth repair.

For the number of square yards of portland cement concrete pavement, placement only, constructed, the contractor will be paid the contract price per square yard. This shall be full compensation for furnishing all labor and equipment necessary to place, finish, texture and groove, and cure the concrete, including the placement of the grout and sawing and sealing the joints, in accordance with the plans and specifications.

B. Surface Preparation. For the square yards of pavement prepared by each method specified - scarification, sand blast, and water blast -, the contractor will be paid the contract price per square yard. This shall be full compensation for preparation of the existing pavement, stockpiling the material, sand blasting, water blasting, air blasting, and placing any material removed on the shoulders adjacent to the resurfacing.

Special surface preparation will be paid for as shown on the plans.

C. Partial-Depth Repair. Partial-depth repair will be paid for at the contract price per square yard. This price shall be full compensation for the removal and stockpiling of the old pavement.

D. Full-Depth Patches. For the number of square yards of full-depth patches placed, the contractor will be paid the contract price per square yard. This price shall be full compensation for removal and disposal of the old pavement.

E. Reinforcing Steel will be paid for in accordance with 2404.10.

Article 1109.03 shall not apply to partial-depth repair and full-depth patches.

PART II

OBSERVATIONS AND RECOMMENDATIONS
SURFACE PREPARATION

MILLING OR SCARIFYING

Since this project was built the terminology for this type of surface preparation seems to have leaned toward calling the process milling and, therefore, this term will be used.

The bond strength as measured in shear seems to be consistently lower with milling as compared to sand blasting or water blasting. One possibility of the cause for this is that in the process of milling, some fracturing of aggregate occurs that is not completely loosened and removed. This could result in a somewhat weakened area at the interface. However, it should be noted that the resulting bond strengths for all surface preparation types has consistently been very good.

The milling process is capable of removing a considerable depth of old concrete thus making it capable of removing concrete at bridge approaches, intersections or under passes where more depth must be removed in order to lay a consistent overlay thickness. Milling has also been used to reprofile existing pavements to take care of unequal settlements or curling so that abrupt changes in the overlay depth do not occur.

SANDBLASTING

This method of preparation has been very successful. It has been less expensive than milling and the average bond strength in most cases has been greater. The depth of removal is not as great as in the milling process, however, a sufficiently "clean" surface can be obtained by this method and has proved very satisfactory.

WATER BLASTING

This method proved to be the least expensive, however, it is noted that most of the delamination on this project is in the high pressure water blast areas. Several of the cores that were taken in the spring of 1980 were deliberately taken in the delaminated areas. Almost all of these indicated an apparent lack of grout at the interface and also the original delamtect notes show that there was delamination shortly after completion. The author believes that bond was never obtained in these areas due to the lack of grout and in some cases using grout that was up to five hours old.

Water blasting has the problem of not being able to remove traffic paint and leaving a wet surface. Where the shoulders are not paved, a wet, soft pad line for the paving train can result.

GROUT

The results of this project and observations on others such as the I-80 project built by the Iowa DOT in Pottawattamie County in 1979 indicate that either a sand-water-cement or a water-cement grout are equally as good for bond. Squeeges were used to spread some of the grout and where the surface was quite smooth, the grout was apparently squeegeed off too clean, thus preventing an adequate bond from forming.

The cores in the delaminated areas of this project show that the grout must be spread in such a way as to insure complete coverage. It is also mandatory that the grout be applied immediately ahead of the concrete, on dry pavement, to insure an adequate bond.

CURE

This project used 0.1234 gallons per square yard of white pigmented curing compound which is twice the normal rate as per the Iowa specifications. This rate was used to insure coverage where we had used transverse grooving for texturing. It was felt that because of the thin layer of concrete that the cure would be very critical and to insure complete coverage, with the transverse texturing, a double application was used. There was a considerable amount of runoff from using this double application even though it was applied in two coats. Some later projects have used one and a-half times the normal rate applied all at once and this seems to be satisfactory.

JOINTS

Much attention has been given to the contraction joints both on this project and later ones. Where the contraction joints are sawed very early, delamination does not seem to occur. This would indicate a need for the joint to be placed in the plastic concrete immediately over the old joint.

This project was built by sawing the contraction joint approximately 1 1/4 inches deep. Upon examining these areas it did control the cracking, however, the expansion of the two slabs cannot be quite uniform due to the fact that the saw joint does not go all the way through the overlay. Later experimentation has shown that the most successful way to control the contraction joints is for sawing the overlay, full depth, over the existing transverse joints as soon as possible.

MIX

On this project super plasticizers as opposed to normal water reducers did not seem to have any significent effect on the bond strength obtained. The mixes with the super plasticizers were harder to handle in that the time from mix to stiffening was quite short and that any delay in the paving operation cause a considerable amount of extra work and in some cases even an inferior finish due to the fact that the concrete had lost its initial plasticity before it could be finished.

CORES

The cores that were taken on this project April 1 and 2, 1980, indicated that the bond strength in shear were very similar to the original cores taken in the same areas. The cores that were taken in the known delaminated areas showed a clean slab, very nearly free of grout, therefore, leading to the strong suspicion that we did not have bond in these areas at any time. The delamtect has shown that we have not lost bond in any place that we originally had bond.

The areas that are delaminated at this time are still performing well. There has been no breaking out of this concrete and therefore no patching. It is felt that patching, however, can be easily done if necessary by taking out the delaminated concrete, applying a grout and a paving mix, such as was used originally.

There are a number of reflection cracks in some of these broken up areas, however in the areas with 3, 4 and 5 inch thicknesses there are very few reflection cracks and none have been noted in the areas where transverse steel was placed.

Results of the shear tests on 1980 cores:

Surface preparation	Ave.
Sand Blasting	752 psi
Water Blasting	626 psi
Milling	410 psi
Milling & Sand Blasting	665 psi

SUGGESTED FUTURE RESEARCH

1. Determine whether super plasticizing water reducers control the shrink of the concrete enough to effect stresses induced at the interface and what effects temperature of the old slab at the time of placement has upon contraction.

2. As a means of possibly lowering the cost of surface preparation, a water blast machine that was capable of injecting sand might be successfully used. This would give enough abrasive to remove paint and other surface contaminants.

3. A shot-blasting machine should be considered as a possible alternative for the surface preparation. This type of machine was not used on this project but would be an alternative method of surface preparation providing its rate of progress would be great enough to stay ahead of the paving train on a full scale paving operation.

4. A simple economical procedure for placing the contraction joints in the plastic concrete needs to be developed. Research in the area of Item I above would help to determine the urgency of this development, however, from observations on several projects the author believes considerable stresses are developed in the overlay concrete as it cures when there is a sufficient change in temperatures. This stress would seem to be the greatest at the contraction joints in the lower slab thus putting the most stress in the bond at the contraction joints. Thus, the possibility of movement between the two slabs at the contraction joint at the critical time of setting might result in breaking a preliminary bond and preventing a sufficient bond from forming.