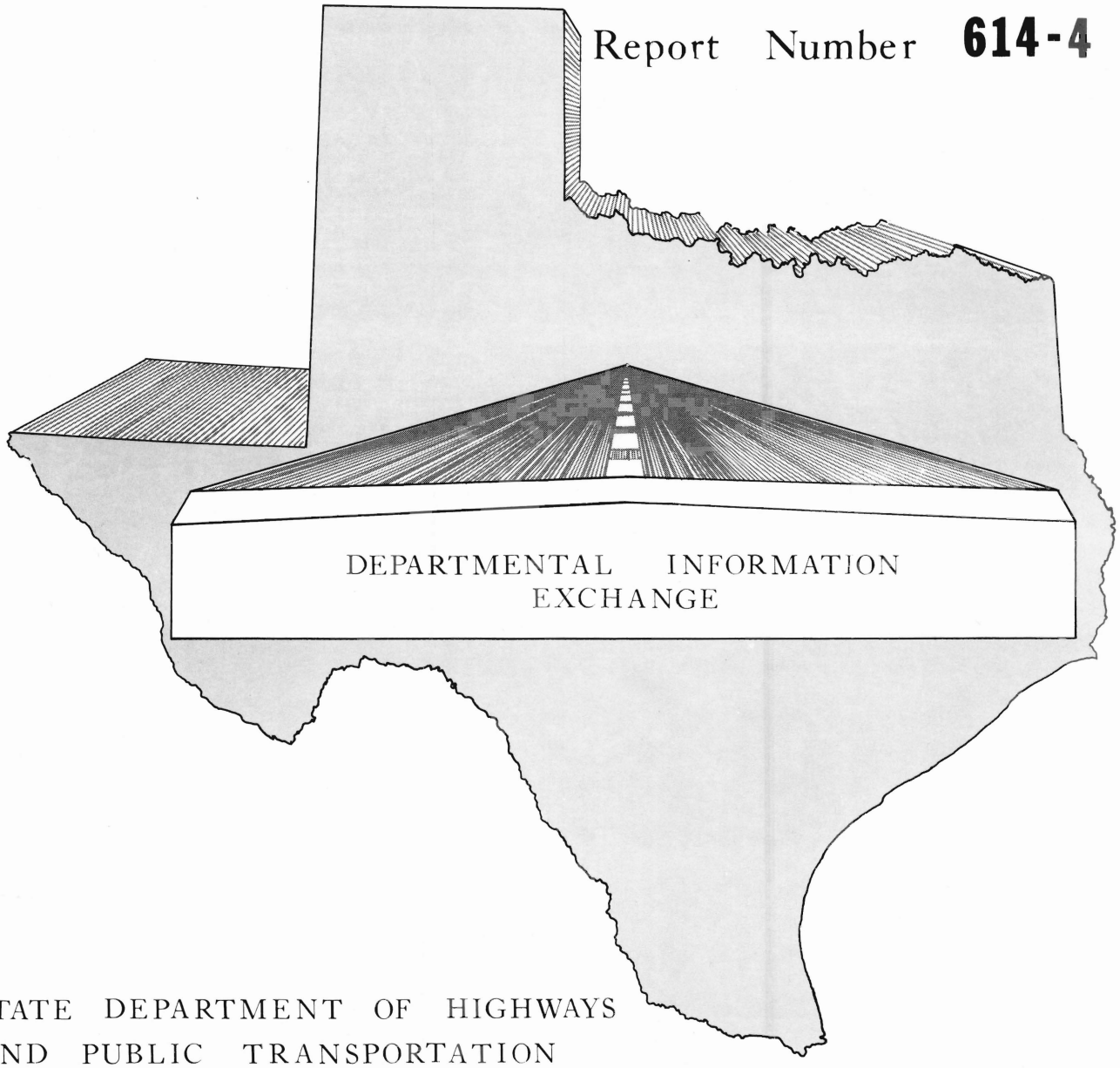
EXPERIMENTAL PROJECTS

HIGH DENSITY CONCRETE AND POLYMER IMPREGNATED CONCRETE BRIDGE DECKS

Report Number **614-4**



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16. Abstract

The performance of a polymer impregnated bridge deck and a dense concrete overlayed bridge deck was evaluated for a period of five years after they were placed under traffic. Visual inspections and corrosion potential surveys were made during the evaluation period.

No problems were encountered during the polymer impregnation operation or the placement of the dense concrete overlay. Both the polymer impregnated deck and the dense concrete overlay continue to perform satisfactorily after five years in service and no evidence of reinforcing steel corrosion has been found. There is a larger number of cracks in the polymer impregnated deck but many of them are quite small and there is no significant differences between the crack patterns of the two decks. Throughout the evaluation period, there was no discernible difference between the performance of the polymer impregnated deck and the dense concrete overlay.

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HIGH DENSITY CONCRETE AND POLYMER IMPREGNATED CONCRETE BRIDGE DECKS

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Austin, Texas

Experimental Projects Report No. 614-4

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U.S. Department of Transportation
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High Density Concrete and Polymer
Impregnated Concrete Bridge Decks

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The material contained in this report is experimental in nature and is published for informational purposes only. Any discrepancies with official views or policies of the State Department of Highways and Public Transportation should be discussed with the appropriate Austin Division prior to implementation of the procedures or results.

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INTRODUCTION

Chloride induced corrosion of the top mat of reinforcing steel and the resulting deterioration of concrete bridge decks has been, and continues to be, one of the major maintenance problems faced by highway agencies. Numerous methods for protecting concrete bridge decks against the intrusion of damaging chloride ions have been tried in the past. The performance of two of these protection methods--partial depth polymer impregnation and high density concrete overlay--is the subject of this report.

Background

In 1971, the University of Texas Center for Transportation Research, in cooperation with the Texas State Department of Highways and Public Transportation (TSDH&PT) and the Federal Highway Administration (FHWA), began a research study entitled "Polymer-Impregnated Concrete for Highway Applications". One of the results of this study was the development of a method for partial depth polymer impregnation of a concrete bridge deck. Laboratory tests, combined with a limited amount of field testing, indicated that partial depth impregnation of concrete with a polymer could significantly increase its ability to resist the intrusion of chlorides and other potentially damaging chemicals.

In order to evaluate the polymer impregnation process and its ability to protect concrete bridge decks against chloride induced damage, the TSDH&PT included it in the plans and specifications for one of the twin structures to be constructed on Interstate Highway 27 north of Lubbock, Texas. The other twin structure was designed to be protected using a high density concrete

overlay which had been used extensively in Iowa and Kansas for bridge deck and pavement restoration projects. Since neither of the proposed protection systems had been approved for general use by the FHWA, the bridges were constructed as an FHWA Category II Experimental Project.

Objective and Work Plan

The objective of this experimental project was to construct one full sized polymer impregnated concrete bridge deck and one full sized deck with dense concrete overlay and evaluate their performance under field conditions.

The work plan for accomplishing the objective of this project was as follows:

1. Provide a complete evaluation of the equipment and construction methods used.
2. Obtain cores from the impregnated deck to ascertain the actual depth of impregnation.
3. Make periodic in-depth inspections of the decks for a period of five years.
4. Make corrosion potential measurements in conjunction with the above inspections.
5. Map any significant cracks that occur.

Description of Bridges

The experimental bridges are twin structures that carry Interstate Highway 27 over County Road 60 approximately two miles north of the north city limits of Lubbock, Texas. Each structure consists of one 207' (50'-107'-50') continuous prestressed concrete beam unit with TSDH&PT Type

54 beams and a 7 1/2" cast in place slab. The overall width of each bridge is 44'-3" with a 42'-0" clear roadway. The deck of the structure carrying the northbound lanes of IH 27 received the polymer impregnation treatment while the one carrying the southbound traffic received the dense concrete overlay.

POLYMER IMPREGNATION

The specifications and procedures used for this project were generally the same as those developed and used for the construction of a polymer impregnated bridge deck in Big Spring, Texas. An in-depth discussion of the development of these procedures and specifications can be found in FCIP Report No. 508-2F, "Polymer Impregnation of New Concrete Bridge Decks", dated October, 1977. The special specification governing the materials and construction methods for polymer impregnation of concrete slabs can be found in Appendix A.

Test Slab

Prior to polymer impregnation of the bridge deck, a 10'x20' reinforced concrete test slab was constructed. The test slab, shown in Figures 1 and 2, was cast on the ground with the same slope and thickness as the bridge slab and was used to evaluate the contractor's proposed equipment and procedures. An analysis of the information and data obtained from this test slab resulted in the monomer application rate being field changed from 0.65 gal/sq yd to 0.80 gal/sq yd.

Deck Preparation

The bridge slab was first sandblasted to remove all contaminates. A concrete block wall was then placed at each end of the section to be impregnated. Each section was the full width of the bridge but was limited to 13'-8" in length because of the amount of heating equipment available on the project. The concrete wall served to protect the section being impregnated against the wind and also as a support for the metal cover over

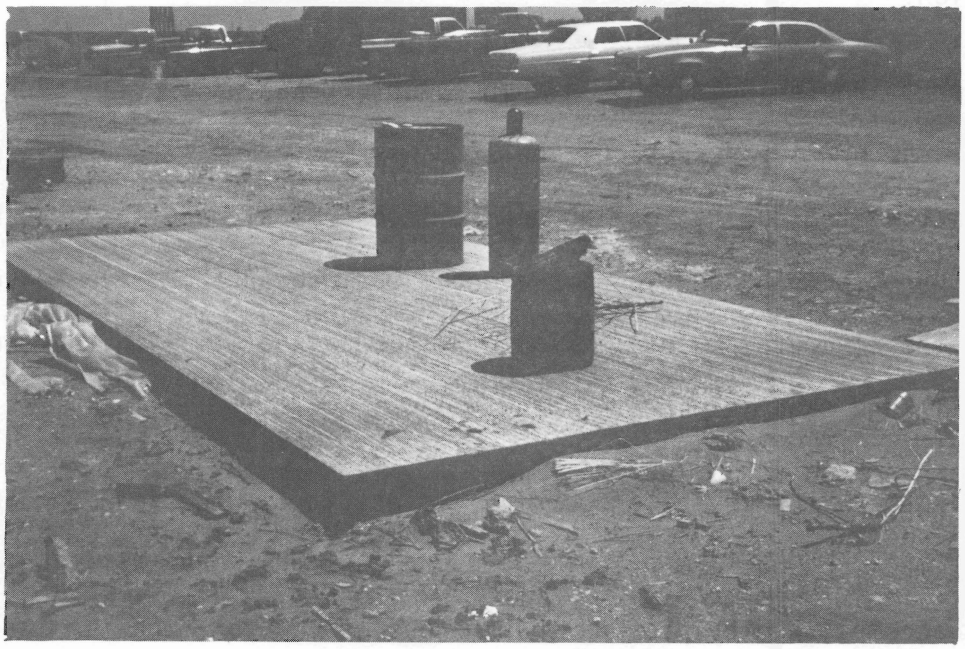


Figure 1. Test Slab

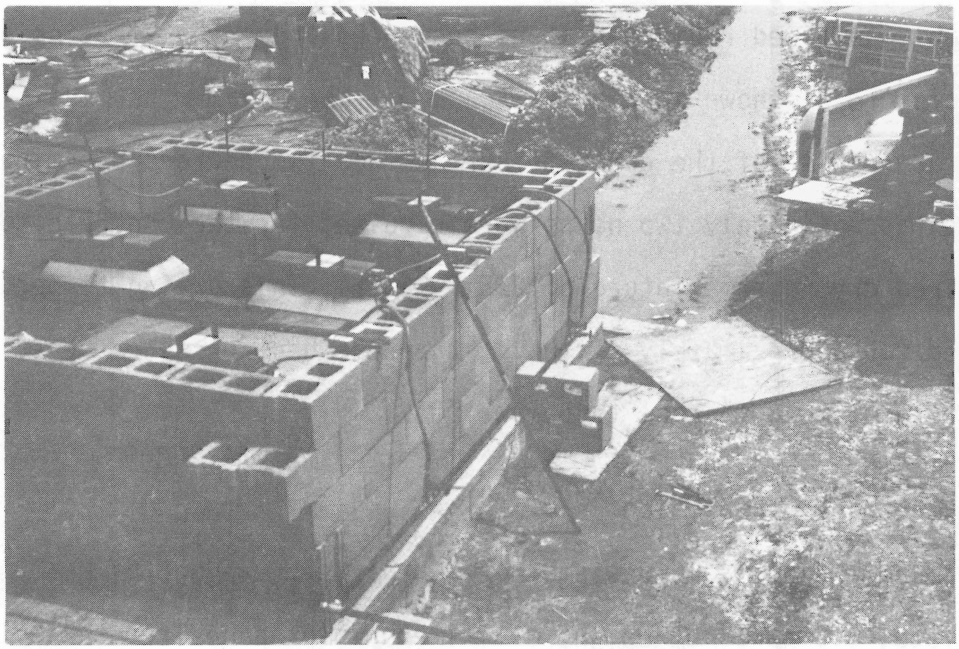


Figure 2. Test Slab with Concrete Block Enclosure in Place

the section.

Prior to beginning drying, a thin layer of sand was spread over the section. The primary purpose of the sand was to serve as a medium to hold the monomer system during soaking and it is essential that the sand be dry for this purpose. The sand also prevented the radiant heat from directly striking the concrete surface. Figure 3 shows a section with the concrete block walls and sand in place.

During both the drying and curing cycles, it is necessary to continuously monitor the temperature to insure that the concrete is not damaged. This was accomplished by placing theremocouples into one quarter inch deep holes drilled into the concrete and connecting them to a potentiometer.

Drying the Deck

With the concrete block walls, sand and thermocouples in place, the section was ready to be heated for the drying phase. Heat for drying was supplied by gas fired radiant heaters suspended above the slab inside a metal enclosure as shown in Figures 4 and 5. The maximum permissible rate of temperature rise of the concrete surface was two degrees per minute; therefore, approximately two hours were required for the concrete to reach the required drying temperature of 225°F-260°F. This drying temperature was maintained for approximately six hours then the heaters were turned off and the concrete allowed to cool to below 100°F.

Applying the Monomer Solution

The monomer solution consisted of 100 parts by weight of Methyl Methacrylate, 5.0 parts by weight of Trimethylolpropane Trimethacrylate, and

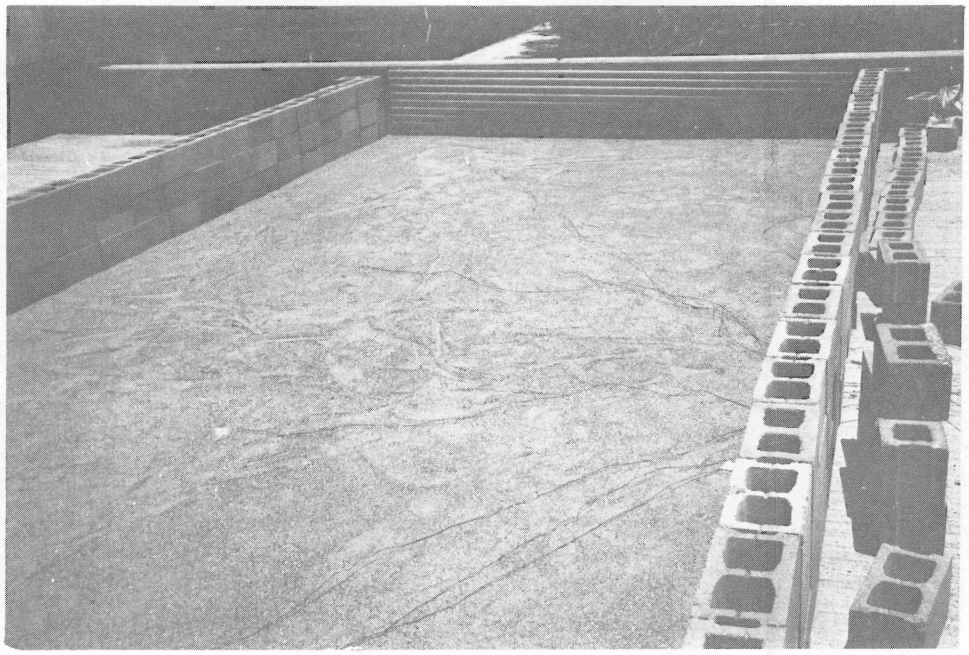


Figure 3. Section of Deck with Concrete Block Walls and Sand Cushion in Place

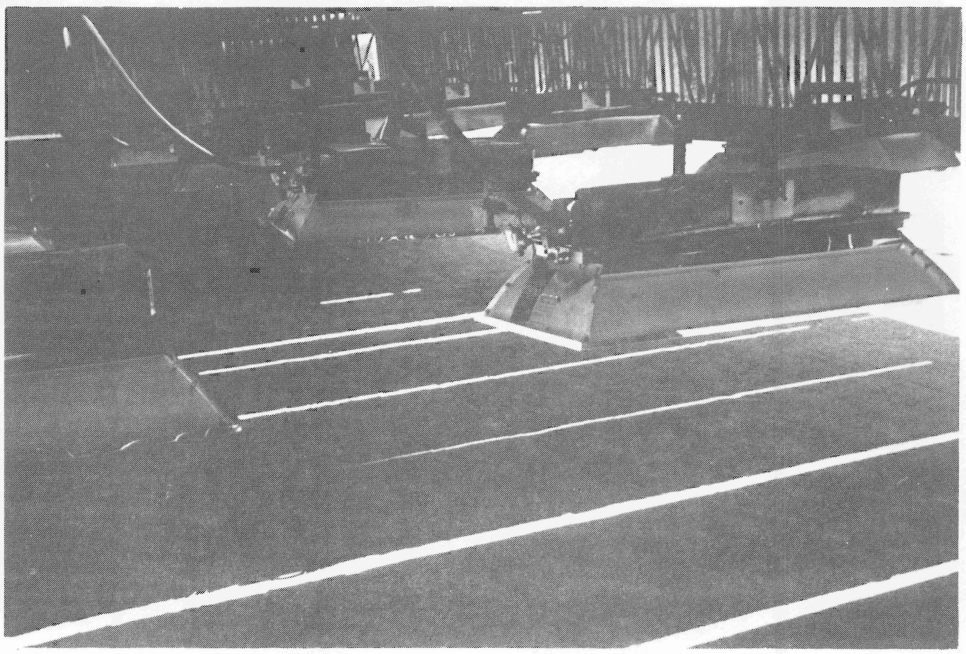


Figure 4. Gas Fired Radiant Heaters

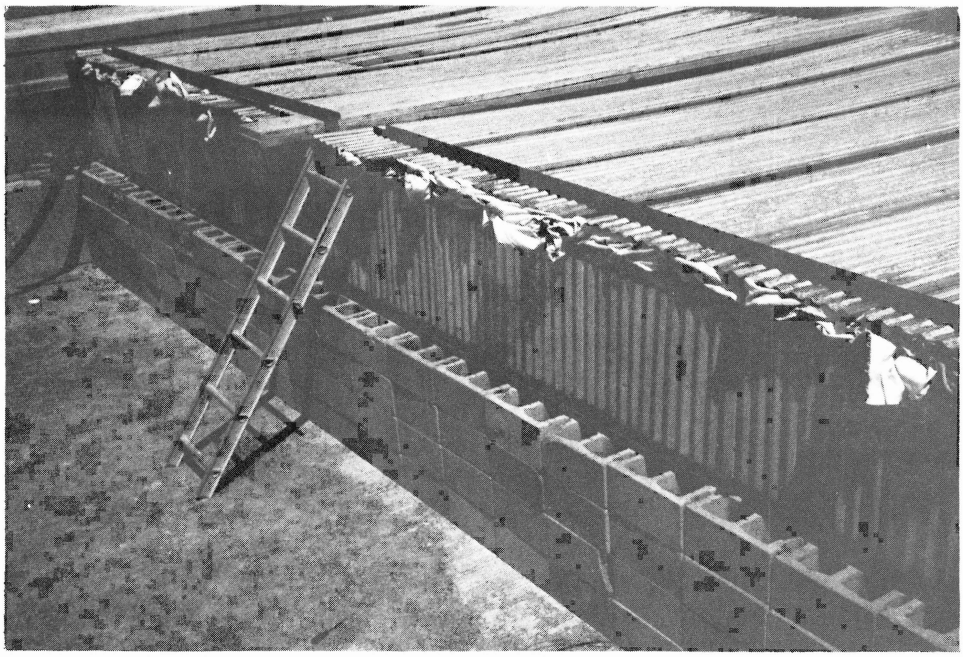


Figure 5. Metal Enclosure Used to Contain Heat During Heating Phases

Figure 6. Placing Monomer

0.5 parts by weight of Azobis (isobutyronitrile). Each section required approximately 40 gallons of the solution. Batch size was limited to a maximum of 30 gallons; therefore, two batches were mixed for each section.

The monomer solution was mixed and applied to the concrete between 3:00 a.m. and 3:30 a.m. As the monomer was placed, it was immediately covered with polyethylene sheeting to retard evaporation of the solution (Figures 6 and 7). The monomer solution was allowed to soak for approximately four hours. The sand was periodically checked for dry areas and if any were found, additional monomer was added.

Polymerization

After the monomer solution had soaked into the concrete, the polymerization phase began. The polyethylene sheeting was removed and the sand layer lightly sprinkled with water. The water served to retard evaportation and also provided some safety against igniting the highly flammable monomer solution. The heaters were then lit and rolled into position. The temperature of the concrete was brought up to 140°F and maintained between 140°F and 175°F for two hours to complete the polymerization phase. Figure 8 shows the heating equipment in place during a curing phase. Note the openings in the top of the enclosure to prevent excessive heat build-up.

Figure 7. Placing Polyethylene Sheeting Over Monomer

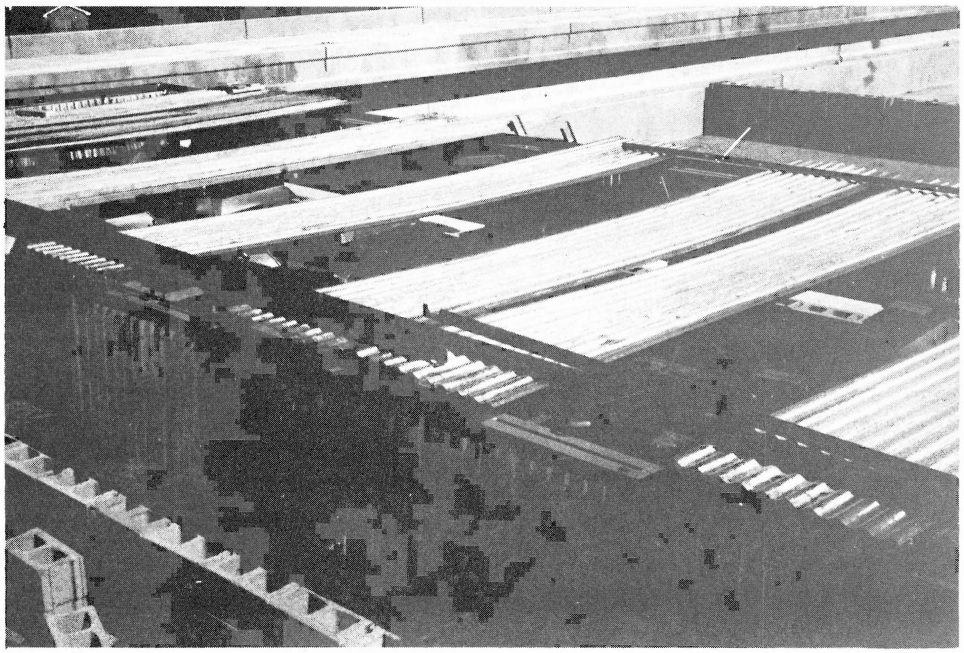


Figure 8. Heating Equipment During Curing Phase

DENSE CONCRETE OVERLAY

The deck of the structure carrying the southbound lanes of IH 27 was constructed in two stages. In the first stage, a 7 1/2-inch slab of conventional Class "C" concrete was placed. Several days later, the 1 1/4-inch dense concrete overlay was placed. Specifications for the dense concrete overlay may be found in Appendix B.

Deck Preparation

The deck was divided into three longitudinal sections for placement of the overlay concrete. Each section was approximately 14 feet wide and 207 feet long. Each section was sandblasted to obtain a uniform surface free of oil, dirt, slurry, and other contaminates. The surface received a final cleaning by air blasting immediately preceeding the grouting operation.

Application of Bonding Grout

To ensure a good bond between the dense overlay and the existing concrete, a thin coating of grout was scrubbed into the dry slab immediately preceeding the placement of the overlay concrete (Figure 9). The grout consisted of equal parts by weight of portland cement and sand, mixed with sufficient water to form a stiff slurry. The rate of progress in applying the grout was controlled to prevent the grout from becoming dry before it was covered with new concrete.

Placing the Overlay

The dense concrete overlay was designed to contain 8.75 sacks of Type II portland cement per cubic yard and have a maximum water/cement ratio

of 3.62 gallons/sack. The design slump was three-fourths of an inch with a tolerance of plus or minus one-fourth of an inch.

Because of the low slump of the concrete and the slow rate of placement, transit mixers are not suitable for dense overlay concrete. A mobile concrete batch truck, shown in Figure 10, was used to mix the concrete for this project. The concrete was transported to the point of placement by an articulated front-end loader, dumped on the slab, and spread by hand (Figures 11 and 12). The concrete was then compacted and screeded to the required elevation by a screed adapted to handle the dense concrete. Figure 13 shows an overall view of the concrete placing operation. Specifications required a placement rate of 40 linear feet per hour; therefore, it took about four hours to complete each section.

Although the required density was obtained after one pass of the screed, several passes of the screed were required to get sufficient grout to the surface for finishing. Hand finishing was required adjacent to the bridge rail and at the armor joints. On the center section, hand finishing was required along the longitudinal joints. The overlay was finished with a transverse tine finish to provide a skid resistant riding surface (Figure 14).

Good consolidation of the overlay concrete is essential to prevent the penetration of harmful chloride ions. Specifications required the overlay concrete to be consolidated to a density equal to 98% of the unit weight of the fresh concrete. Using a nuclear density gauge (Figure 15), in-place densities were measured at several locations. In-place densities ranged from 98.67% to 106.77% with an average of 101.51%.

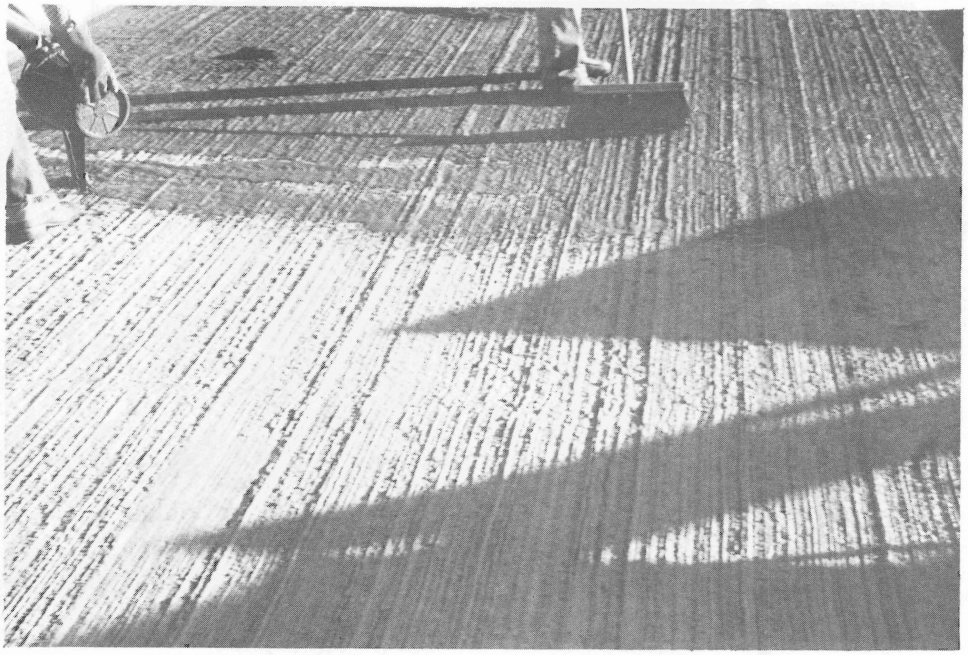


Figure 9. Brushing Grout on Slab Prior to Placing Dense Concrete Overlay

Figure 10. Mobile Concrete Batch Truck

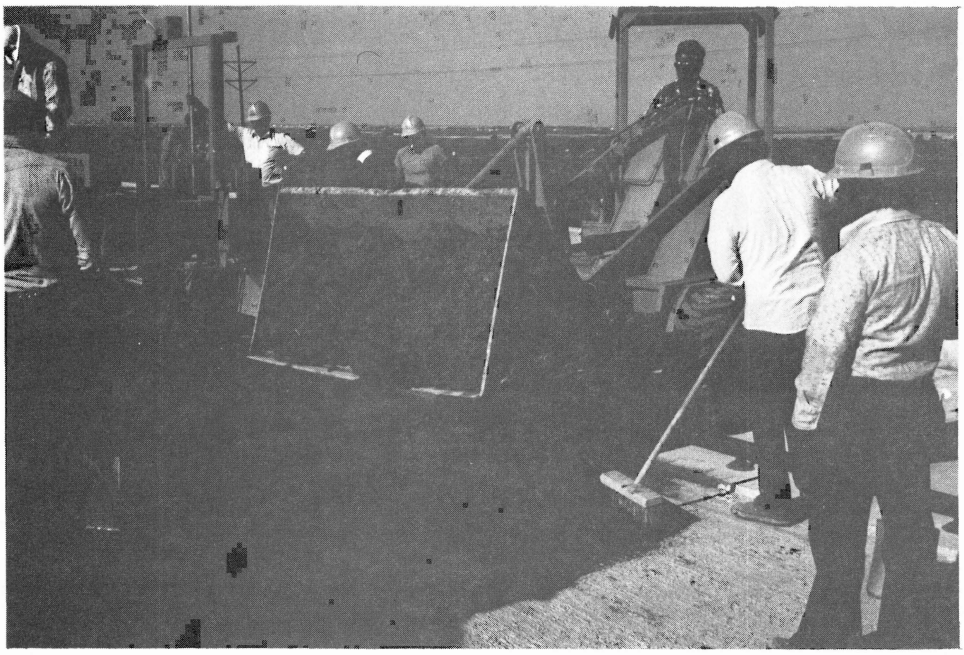


Figure 11. Dumping Concrete from Front End Loader

Figure 12. Spreading Overlay Concrete

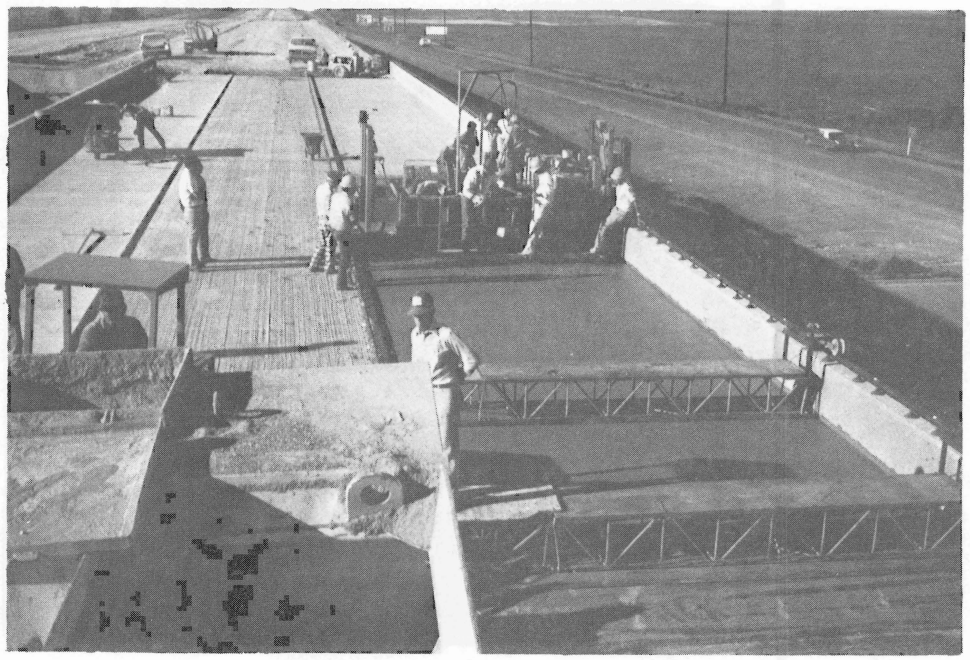


Figure 13. Overall View of Overlay Concrete Placement

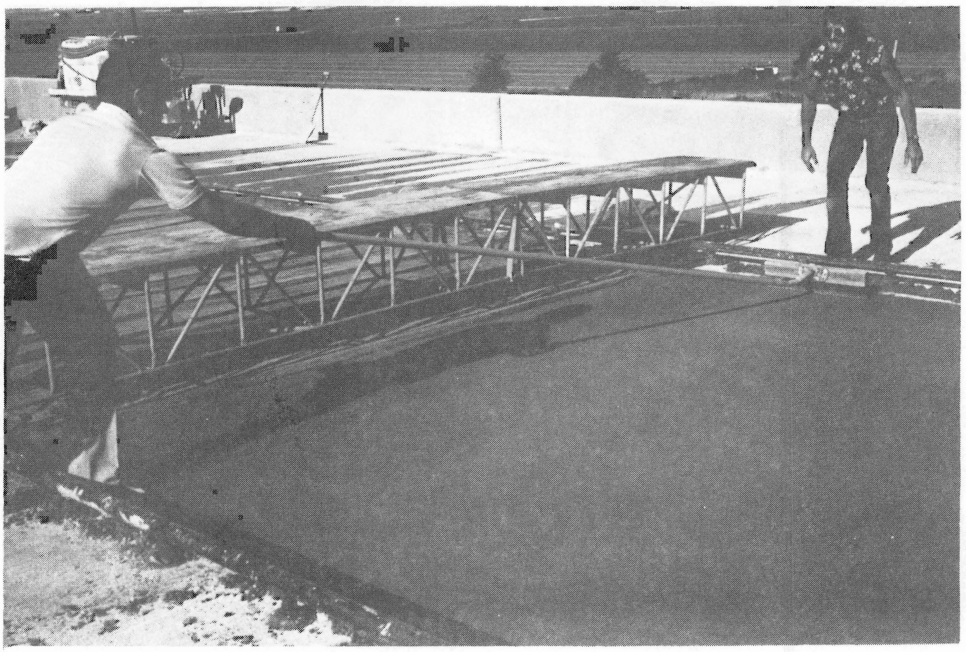


Figure 14. Finishing Overlay Concrete

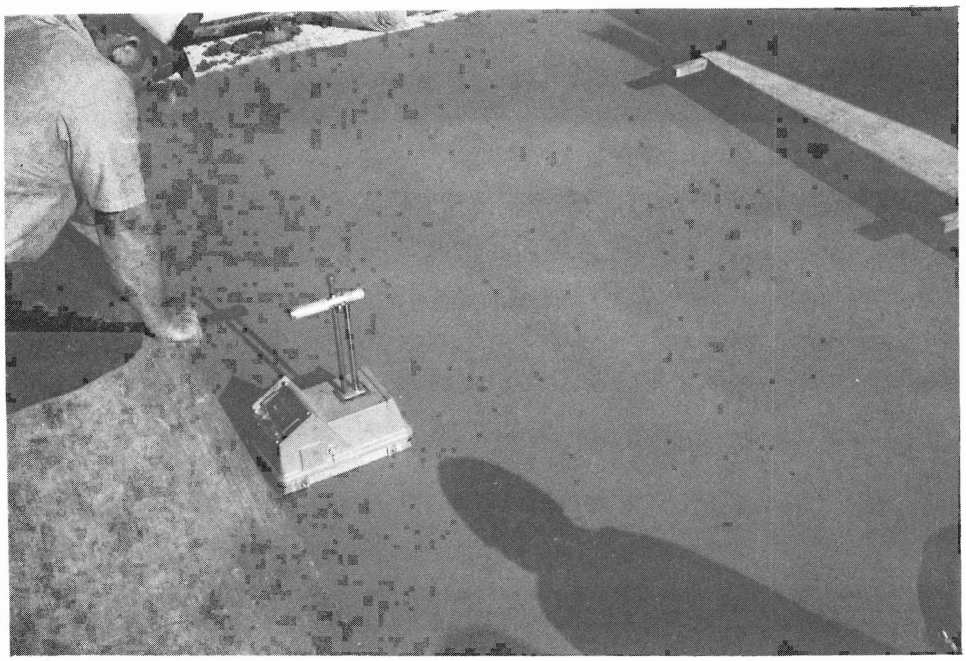


Figure 15. Measuring Density With Nuclear Density Gauge

TESTS PERFORMED

Corrosion Potential Surveys

Four corrosion potential surveys, using a copper sulfate half-cell as the reference electrode, were made on each bridge deck during the evaluation period, the first survey being made before the bridges were opened to traffic. Subsequent surveys did not reveal any evidence of active corrosion. The data for all of the corrosion potential surveys may be found in Appendix C.

Crack Surveys

A crack survey was made on each of the two bridges and the results are shown in Figure 16. The polymer impregnated deck was surveyed in 1978 shortly after polymerization and the dense concrete overlay was surveyed in 1980. Visual inspections of these decks were made throughout the evaluation period and no significant changes have occurred.

Depth of Penetration

In order to determine the depth of penetration of polymer impregnation, one core was taken from each finished section for examination. The depth of penetration in some cores could be determined by the darker color of the polymer. For a positive determination of depth, however, the cores were dipped in a 10% hydrochloric acid solution. The acid attacks the mortar and not the polymer, therefore the penetration could easily be determined. Twenty-two cores were examined and penetration depths ranged from 0" to 1 1/8". Figure 17 shows the location of each core and the depth of polymer at that location.

The three cores that had little or no polymer penetration were taken from near the edges of treatment sections. This area is where the polethylene film was weighted down with concrete blocks. While there is no proof that this was the cause for the lack of penetration, it was noticed that the sand under these concrete blocks appeared to be dryer than the surrounding sand.

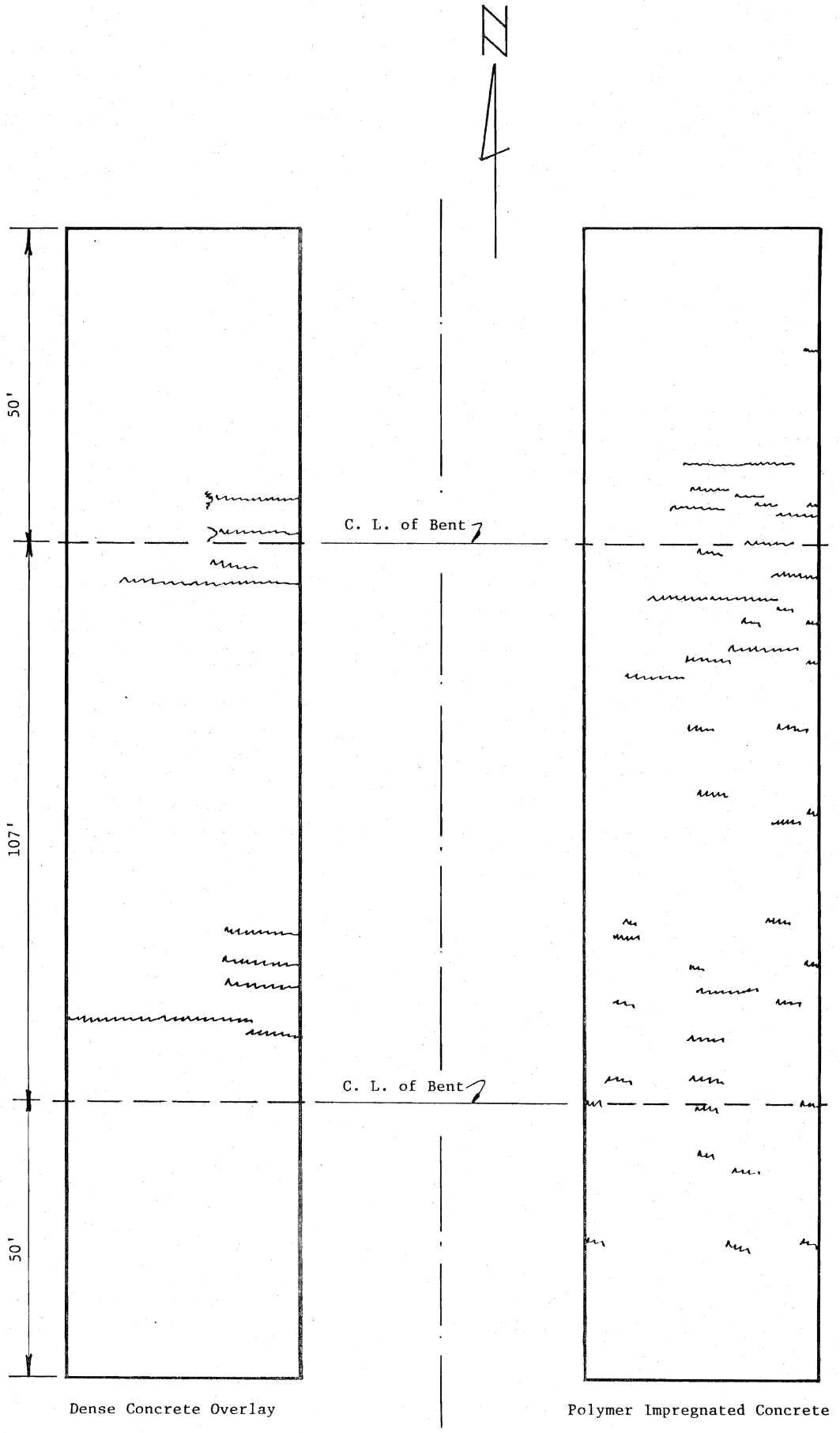


Figure 16. Plot of Major Cracks

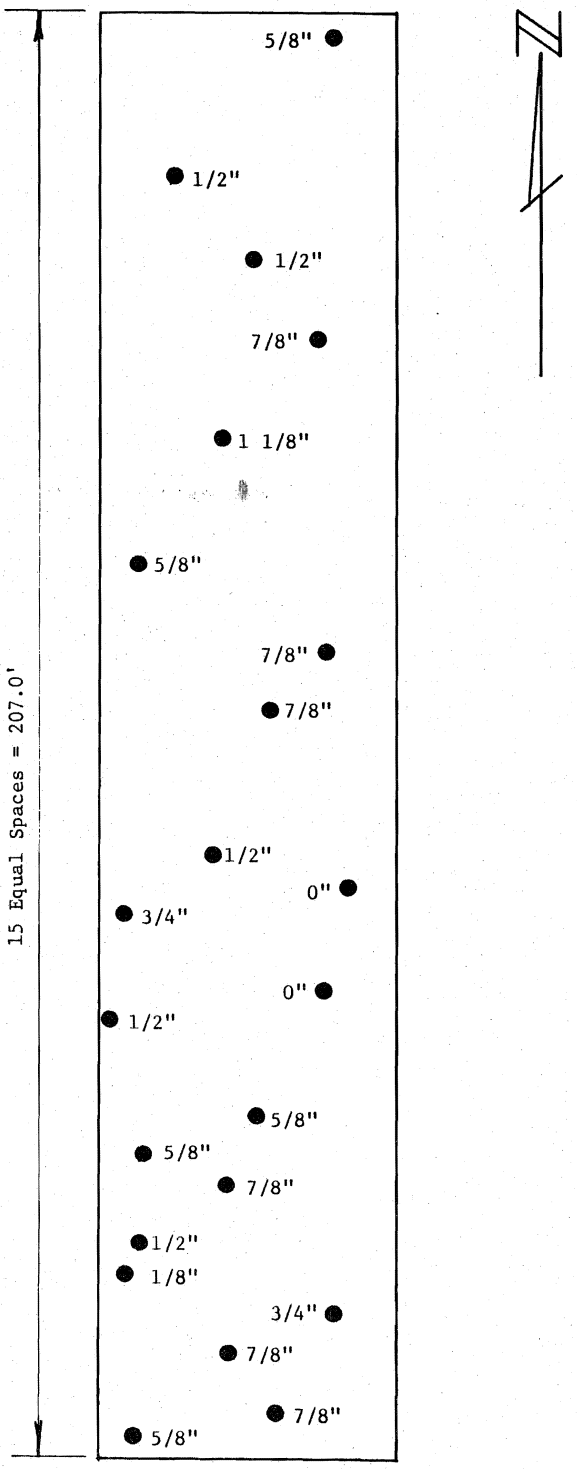


Figure 17. Location of Cores and Depth of Polymer Penetration

CONCLUSIONS

Based upon the results of tests and observations made during construction and a five-year evaluation period, the following conclusions are made:

1. No major problems were encountered during the polymer impregnation operation or the placement of the dense concrete overlay.
2. Both the polymer impregnated bridge deck and the dense concrete overlay continue to perform satisfactorily after five years in service.
3. There was no evidence of reinforcing steel corrosion found during any of the corrosion potential surveys.
4. Although there is a larger number of cracks in the polymer impregnated deck, many of them are quite small and there are no significant differences between the crack patterns of the two decks.
5. There has been no apparent increase in the amount of slab cracking since the structures were opened to traffic in 1980.
6. During the evaluation period, there was no discernible difference between the performance of the polymer impregnated deck and the dense concrete overlay.

APPENDIX A

SPECIAL SPECIFICATION
POLYMER IMPREGNATION OF CONCRETE SLABS

TEXAS HIGHWAY DEPARTMENT

SPECIAL SPECIFICATION

ITEM 4127

POLYMER IMPREGNATION OF CONCRETE SLABS

4127.1. Description. This item shall govern for the materials and the construction methods required for polymer impregnation of concrete slabs in accordance with the plans and these specifications.

4127.2. General. The Contractor shall submit detailed plans and procedures for polymer impregnation at least 60 days prior to the demonstration required herein. This submission shall include materials to be used, type and size of equipment and apparatus, provisions for storage of monomer ingredients, mixing of monomer solution, the proposed impregnation pattern of the deck, and necessary safety precautions.

4127.3. Demonstration Impregnation. A minimum of two weeks prior to impregnation of the bridge slab, the Contractor shall demonstrate his proposed procedures and equipment on a reinforced concrete slab cast on the ground at the site. The reinforcement shall be No. 4 bars on 6 inch centers, in both directions at approximately 2 inches below the top of the slab. The slab shall have the same thickness used in the bridge, have a minimum area of 150 square feet, and be of the same mix design to be used in the bridge slab. The slab shall be placed on a vapor barrier and shall have a 5 percent grade in one direction. The surface texture shall be the same as that used on the bridge. Cores will be taken to evaluate the depth and the quality of impregnation. The demonstration shall also be used to evaluate equipment and procedures.

4127.4. Materials. The monomer solution shall consist of 100 parts by weight of monomer, Methyl Methacrylate, MMA, as produced by Rohm and Haas Company or an approved equal; 5.0 parts by weight of a crosslinking agent, Trimethylolpropane Trimethacrylate, TMPTMA (X-980), as produced by Rohm and Haas Company or an approved equal; and 0.5 parts by weight of the polymerization initiator, Azobis (isobutyronitrile), AIBN (VAZO 64), as produced by E.I. Dupont Company or an approved equal.

The MMA shall have a minimum purity 99.8 percent, and shall contain an inhibitor, MEHQ (methyl ester of hydroquinine) in an amount not less than 9 ppm nor more than 12 ppm as supplied by the manufacturer.

The TMPTMA shall have a minimum purity of 95 percent and contain not less than 80 ppm nor more than 100 ppm of HQ (hydroquinine) inhibitor.

AIBN shall have a minimum purity of 96 percent.

The Contractor shall furnish certification from the materials supplier that the materials meet the requirements of this specification. Further testing, as required, will be done by the Department.

4127.5. Storage and Handling. The Contractor shall obtain from the manufacturer detailed information on safe practices for storage, handling and disposal of these materials and also their explosive and flamability characteristics, health hazards and recommended fire fighting equipment.

Individual materials shall be stored in accordance with the manufacturer's recommendations and in a manner that prevents the materials from becoming contaminated in any way by foreign substances. The AIBN shall not be stored in the same structure or vehicle as the MMA, or the TMPTMA, until just prior to mixing, and then only the specific amounts to be used for a given batch shall be brought into the same area.

Once these ingredients have been mixed, the resulting mixture shall be regarded as a highly reactive material which is more dangerous than any of the individual ingredients separately. Suitable fire extinguishers shall be located near the mixing and application area. Further information on fire safety may be found in "Chemical Safety Data Sheet", SD-79, from Manufacturing Chemists Association, 1825 Connecticut Avenue, N. W., Washington, D.C. 20009.

4127.6. Mixing. The individual ingredients for the monomer solution shall be premeasured to yield 100 parts of MMA, 5 parts of TMPTMA and 0.5 parts of AIBN, proportioned by weight, in the final mixture.

All mixing shall be done in an unenclosed, shaded area. Mixing shall proceed by introducing the MMA into a suitable container. The AIBN shall then be added and mixed until no undissolved particles of AIBN are evident. The TMPTMA should then be added and mixed. In no case shall the mixing time be less than 5 minutes. Samples will be taken for testing to insure that the mixture will polymerize at the desired rate.

The mixture shall be prepared in batches of not greater than 30 gallons.

The temperature of the mixture during preparation and application shall be between 40F and 80F.

The mixture must be applied within 30 minutes after completion of mixing. A longer time before application will be permitted at lower temperatures provided the Contractor can demonstrate that the procedure is safe and that adequate depth of impregnation is obtained.

Portions of a given batch or batches which have become unsatisfactory for use shall be disposed of by incineration under controlled conditions in a safe open area, or incorporated into a land fill, all in accordance with applicable federal, state and local regulations.

4127.7. Construction Methods. Not sooner than 28 days after placement of the concrete to be treated, the monomer solution shall be applied to the concrete surface within the limits shown in the plans.

The surface of the concrete shall be swept clean to remove all foreign material. Substances such as oil or grease which cannot be removed by sweeping shall be cleaned with an approved solvent and/or sandblasting. The surface shall be cleaned not more than 4 hours prior to application of heat for drying. Any solvents used shall be allowed to evaporate completely prior to heat application.

The deck shall be dried by a method determined by the Contractor. The heat source may include, but not necessarily be limited to, open flame burners, infrared heaters, warm forced air, or heat lamps. Adequate enclosures shall be provided to concentrate and confine the heat.

The intensity of heat application shall be rigidly controlled to insure that the rate of temperature rise of the concrete surface shall not exceed 2 degrees per minute, and in no case shall there be evidence of sooting, charring, spalling or cracking of the concrete. The drying temperature on the surface of the concrete shall be uniform and maintained between 225F and 260F for 5 hours. Caution shall be exercised to prevent localized temperatures in excess of 260F.

The Contractor shall install heat sensing devices on the concrete surface, one per 100 square feet, at locations approved by the Engineer, which will continuously record the surface temperature.

The sand cover required herein may be applied to the surface before the application of heat in order to dry the sand.

As nearly as possible, the areas to be dried at one time shall be approximately symmetrical with respect to the structure centerline to minimize the unsymmetrical longitudinal expansion of the deck.

Any surface damage caused by the drying process shall be repaired by approved methods prior to monomer impregnation.

The monomer solution shall be applied within 24 hours after completion of drying and while the temperature of the surface of the concrete is between 50F and 90F. Cooling of the surface to within the above temperature range may be accelerated by blowing dry air over the surface.

Clean dry concrete sand or blast sand shall be applied to the surface to a depth of three eighths to one half of an inch prior to application of the monomer solution. (The sand may be damp if applied prior to drying.) The purpose of the sand is to hold the monomer solution on the surface during the soaking period. Other materials such as dry burlap or blankets may be used if they are shown to perform adequately.

While the slab is being cooled and during the time the monomer solution is being applied and soaking into the concrete, the surface area being impregnated shall be shaded and protected from sunlight and moisture by an enclosure. In addition, a polyethylene membrane shall be placed on the surface of the

concrete or sand during cooling and the sand during soaking for the purpose of preventing moisture from high relative humidity and other sources from entering the dry sand covering and/or the concrete.

The monomer solution shall be applied uniformly to the surface at the approximate rate of sixty five one-hundredths (0.65) gallons per square yard. The monomer solution shall be carefully sprayed so as not to erode the sand cover. The sand surface shall be covered with polyethylene sheeting as soon as possible after application of the monomer solution. The polyethylene shall be weighted to hold it in place.

The monomer solution shall be allowed to soak into the concrete from 4 to 6 hours. If the sand cover becomes dry, additional monomer solution shall be applied.

During application and soaking, the monomer solution shall be confined to the area being impregnated. It shall not be allowed to run or be sprayed onto previously impregnated surfaces. A slight overlap of areas will be permitted to insure that the bridge deck is impregnated throughout the designated limits.

Excess monomer solution shall not be permitted to run down the bridge deck or through expansion joints or holes in the deck. Inert material, such as dry sand, shall be used to soak up excess runoff.

Suitable fire precautions shall be taken during the application and soaking period, during which time no open flame, drying or otherwise, shall be closer than 25 feet to the area being impregnated or to the mixing area.

Immediately after the required soaking period, the impregnated surface shall be cured by application of heat. The surface temperature of 140F for curing shall be attained in not more than 2 hours and maintained between 140F and 175F for 2 hours. The heat source may be steam, ponded hot water or forced warm air. Open flame heat will not be permitted.

The method of heat application and distribution shall be such as to insure uniform surface temperature and avoid localized hot spots. During heat application, the polyethylene sheeting shall remain in place on the surface to minimize evaporation.

The cover shall be removed after curing is completed. Any sand which has bonded to the slab to a depth of one fourth of an inch or more, or where a rough riding surface results, shall be removed to the satisfaction of the Engineer.

4127.8. Measurement. The work required for polymer impregnation of the concrete slab will be measured by the square yard. This includes sixty five one-hundredths (0.65) gallons of monomer solution, 5 hours drying time, 4 to 6 hours soaking time and 2 hours curing time, per square yard.

4127.9. Payment. Payment for polymer impregnation of concrete slabs will be at the unit price bid per square yard, measured as prescribed above, which payment shall be full compensation for the demonstration impregnation; for all testing; for furnishing and applying monomer solution, sand, blankets, membranes and enclosures; for all cleaning, drying and curing; for all labor, tools, materials, equipment and incidentals necessary to complete the work and for all special facilities and equipment for storage of materials and fire precautions.

APPENDIX B

SPECIAL SPECIFICATION
DENSE CONCRETE OVERLAY

STATE DEPARTMENT OF HIGHWAYS AND PUBLIC TRANSPORTATION

SPECIAL SPECIFICATION

ITEM 4134

DENSE CONCRETE OVERLAY

4134.1. Description. This item shall govern for overlaying of new bridge decks with a high density portland cement concrete in accordance with the details shown on the plans and the requirements of this specification.

4134.2. Materials. All materials shall conform with the respective requirements of the Item, "Concrete for Structures", with the following exceptions:

(1) Cement. Portland cement shall be Type II. The same brand of cement shall be used throughout for overlaying any one structure.

(2) Coarse Aggregate. The coarse aggregate shall be crushed stone, containing no chert or shale, having an absorption not exceeding 3 percent and conforming with the following gradation:

Sieve Size	Percent Retained
3/4	0
1/2	0-3
3/8	10-60
No. 4	70-100

(3) Concrete. The concrete shall be designed to contain 8.75 sacks of cement per cubic yard with a water/cement ratio not exceeding 3.62 gallons per sack. The absolute volume of fine aggregate shall be approximately equal to that of the coarse aggregate.

The entrained air content of the fresh concrete, as determined in accordance with ASTM Designation: C231 by vibration, shall be 6 percent, with a tolerance of plus or minus one percent.

A water reducing admixture for improving workability will be required.

The slump, measured in accordance with Test Method Tex-415-A, shall be three fourths of an inch with a tolerance of plus or minus one fourth of an inch.

Concrete strength requirements shall be as specified on the plans. Strength specimens shall be fabricated in accordance with ASTM Designation: C-31 by vibration.

Ready mix concrete will not be approved.

(4) Grout. The grout for bonding new concrete to existing concrete shall consist of equal parts by weight of portland cement and 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 existing concrete in a thin, even coating that will not run or puddle in low spots. For sealing vertical joints between adjacent lanes of overlay, the grout may be thinned to a suitable consistency.

4134.3. Equipment. The equipment used shall be subject to the approval of the Engineer and shall comply with the following:

(1) Surface Preparation Equipment. The surface preparation equipment shall be as follows:

(a) The sawing equipment shall be capable of sawing concrete to the specified depth of overlay.

(b) The scarifying equipment shall be a power-operated, mechanical scarifier capable of uniformly scarifying or removing the existing concrete to a depth of one fourth of an inch.

(c) Sandblasting equipment shall be capable of removing oil, dirt, slurry, etc., which may contaminate the scarified surface.

(2) Proportioning and Mixing Equipment. This equipment shall meet the requirements of the Item, "Concrete for Structures", except as follows:

(a) Ready-mix concrete shall not be used.

(b) The mixer shall be equipped with an approved automatic device for timing the mix and locking the discharging device

to assure the required mixing period. The timer shall operate a device that plainly signals the completion of mixing time. Approved admixture dispensing devices shall also be provided. The mixing time may be varied by the Engineer to produce unifor and adequately mixed concrete.

(3) Placing and Finishing Equipment. Sufficient and appropriate hand tools for placing and finishing stiff plastic concrete and for working to correct level for strick-off shall be provided.

A finishing machine complying with the following requirements shall be used. It shall be inspected and approved by the Enginee prior to use on each project.

A mechanical strike-off shall be required to provide a uniform thickness of concrete in front of the oscillating screed.

At lease one oscillating screed shall be designed to consolidate the depth of concrete overlay to 98 percent of the unit weight, determined in accordance with ASTM Designation: C138 by vibration A sufficient number of identical vibrators shall be effectively installed such that at least one is provided for each 5 feet of screed length. The bottom face of this screed shall be at least 5 inches wide with a turned up or rounded leading edge to minimiz tearing of the surface of the plastic concrete. Each screed shal have an effective weight of at least 75 pounds for each square foot of bottom face area. Each screed shall be provided with positive control of the vertical position, the angle of tilt and the shape of the crown.

Design of the finishing machine together with appurtenant equipme shall be such that positive machine screeding of the plastic concrete will be obtained within one inch of the face of the existin curb or parapet wall. The length of the screed shall be sufficie to extend at least 6 inches beyond the line where a sawcut is intended to form the edge of a subsequent placement section, and shall overlap the sawn edge of a previously placed course at least 6 inches.

The finishing machine shall be capable of forward and reverse motion under positive control. Provision shall be made for raising the screeds to clear the screeded surface for traveling in reverse.

Supporting rails upon which the finishing machine travels will be required on all overlay projects. The support for these rails shall be fully adjustable (not shimmed) to obtain the correct profile.

The finishing machine shall be equipped to travel on and screed off of any adjacent completed lane without damaging it.

The finishing machine shall be so designed that, when concrete is being mixed and placed under normal operating conditions, the elapsed time between depositing the concrete on the floor and final screeding shall not exceed 10 minutes.

Manual type screeds with approved vibrators shall be used to consolidate and finish small or irregular areas inaccessible to the finishing machine.

The overall combination of labor and equipment for proportioning, mixing, placing, and finishing concrete overlay shall produce approximately 40 linear feet of finished overlay per hour.

Two movable work bridges shall be provided at all times during concrete placement. One work bridge shall be used for checking density, surface finishing and texturing. One work bridge shall be used to cover the overlay with wet burlap.

The Contractor shall furnish the Engineer, for his approval, a work plan including equipment and manpower before work is started.

4134.4. Preparation of Surface. The existing concrete slab area shall be uniformly scarified to a depth of one eighth to one fourth of an inch and to the limits shown on the plans. Removal to a greater depth may be required at drains and elsewhere, as directed by the Engineer.

That portion of the curb or parapet wall against which overlay concrete is to be placed shall be sandblasted. The thickness of concrete to be placed upon the prepared surface shall be specified on the plans. The screed clearance shall be checked in the following manner before concrete is placed:

A filler block having a thickness one eighth inch less than overlay thickness shall be attached to the bottom of the screed; with screed guides in place, the screed shall be passed over the area to be concreted. As an alternate to passage of the finishing machine, an approved template, supported by the screed guides, may be passed over the overlay area. When conditions do not allow use of this method, a stringline or other means shall be used, subject to approval of the Engineer. All concrete which does not have sufficient clearance shall be removed.

As far as practical, scarified surfaces shall be kept free of slurry produced by wet sawing of concrete joints. All such slurry shall be removed from prepared areas before new concrete is placed.

Immediately before applying grout in preparation for placement of new concrete, the surface shall be cleaned with a filtered air blast. If necessary to remove oil or other foreign material, chipping or sandblasting followed by filtered air blasting will be required. It is not intended that existing concrete prepared for overlay, be presaturated with water before grout and new concrete is placed. The prepared surface shall be dry to allow some absorption of the grout.

4134.5. Proportioning and Mixing of Concrete Materials. Applicable provisions of the Item, "Concrete for Structures" shall govern with the following exceptions and additional provisions:

Concrete shall be proportioned and mixed at the project site.

The 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.

A continuous mixer or mortar mixer, using volumetric measurements may be used for mixing grout.

4134.6. Placing and Finishing Concrete. Rails upon which the screed travels shall be placed and fastened in position to insure finishing the concrete to the required profile and shall be placed outside the area to be overlayed if possible. Anchorage of supporting rails shall provide for horizontal and vertical stability; positive anchorage may be required by the Engineer. A hold-down device shot into concrete will not be permitted unless the concret is to be subsequently resurfaced. Plans for anchoring support rails shall be submitted to the Engineer for approval.

The maximum width of concrete overlay placed on bridge floor in one pass shall not exceed 26 feet. If width of bridge to be overlayed exceeds 26 feet, more than one placement will be necessary to overlay the bridge. Location of longitudinal joints shall be as shown on the plans or as approved by the Engineer. At transver and longitudinal joints, the overlay course previously placed shal be sawed to a straight and vertical edge before the adjacent overl course is placed.

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.

The new concrete shall be manipulated and mechanically struck off slightly above final grade. It shall then be mechanically consolidated to 98 percent of the unit weight, determined in accordance with ASTM Designation: C138 by vibration and screeded to final grade. Hand finishing with a wood float may be required for producing a tight, uniform surface.

All vertical joints with adjacent concrete shall be sealed by painting with thinned grout as the finishing is being completed.

After the joint painting is completed, the surface shall receive a "Tine" finish and shall be promptly covered with a single layer of clean, wet burlap. The burlap shall be wet but well drained, and shall be placed as soon as the surface will support it without deformation.

4134.7. Curing. It is intended that the surface receive a wet burlap cure for at least 72 hours. For the first 24 hours, the burlap shall be kept continuously wet by means of a sprinkling or wetting system. After 24 hours, the Contractor may cover the wet burlap with a layer of 4 mil polyethylene film for a minimum of 48 hours in lieu of using a sprinkling or wetting system.

Failure to apply wet burlap within 30 minutes after the concrete has been deposited on the floor shall be cause for rejecting the work so affected; however, if the concrete is revibrated with initial vibration, this time limit will be extended 15 minutes. Surface concrete in the rejected area shall be removed and replaced at no additional cost to the Department.

The Engineer may require the Contractor to place concrete during the night hours if temperature and wind conditions are such that curing techniques are not adequate to protect the concrete. The Engineer will inform the Contractor, in writing, if night placements become necessary. The Contractor will not be due additional compensation.

4134.8. Concrete Surface Treatment. The overlay shall be sealed with a linseed oil solution in accordance with the Item, "Concrete Surface Treatment" unless otherwise noted on the plans.

4134.9. Limitation of Operations. During the construction period of this project, the Contractor shall provide such traffic controls as required on the plans and by the specifications. In the event that the Engineer requests the Contractor, in writing, to provide floodlighting in order to place concrete during night hours, sufficient lighting will be provided as necessary to make quality workmanship and adequate inspection possible. The Engineer shall approve the adequacy of such lighting before operations are begun. The Contractor shall exercise reasonable care to avoid interruptions when placing concrete during night hours, promptly repairing any damage to the lighting system and replacing all burned out lamps.

No loads, other than construction equipment for the overlay, shall be permitted on any portion of the bridge deck after it has undergone cleaning of old concrete and before new concrete has been placed.

No equipment shall be permitted on a finished overlay for 72 hours after placement. In addition, no preparation work shall be performed on the lane adjacent to new concrete during the specified curing period. At temperatures below 55 degrees F, the Engineer may require a longer curing time.

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

Opening completed overlays to traffic shall be in accordance with Article 420.3 of the standard specifications.

4134.10. Measurement. Dense Concrete Overlay will be measured by the square yard of roadway surface area based on the dimension shown on the plans.

Measurement of the linseed oil application shall be in accordance with the Item,"Concrete Surface Treatment".

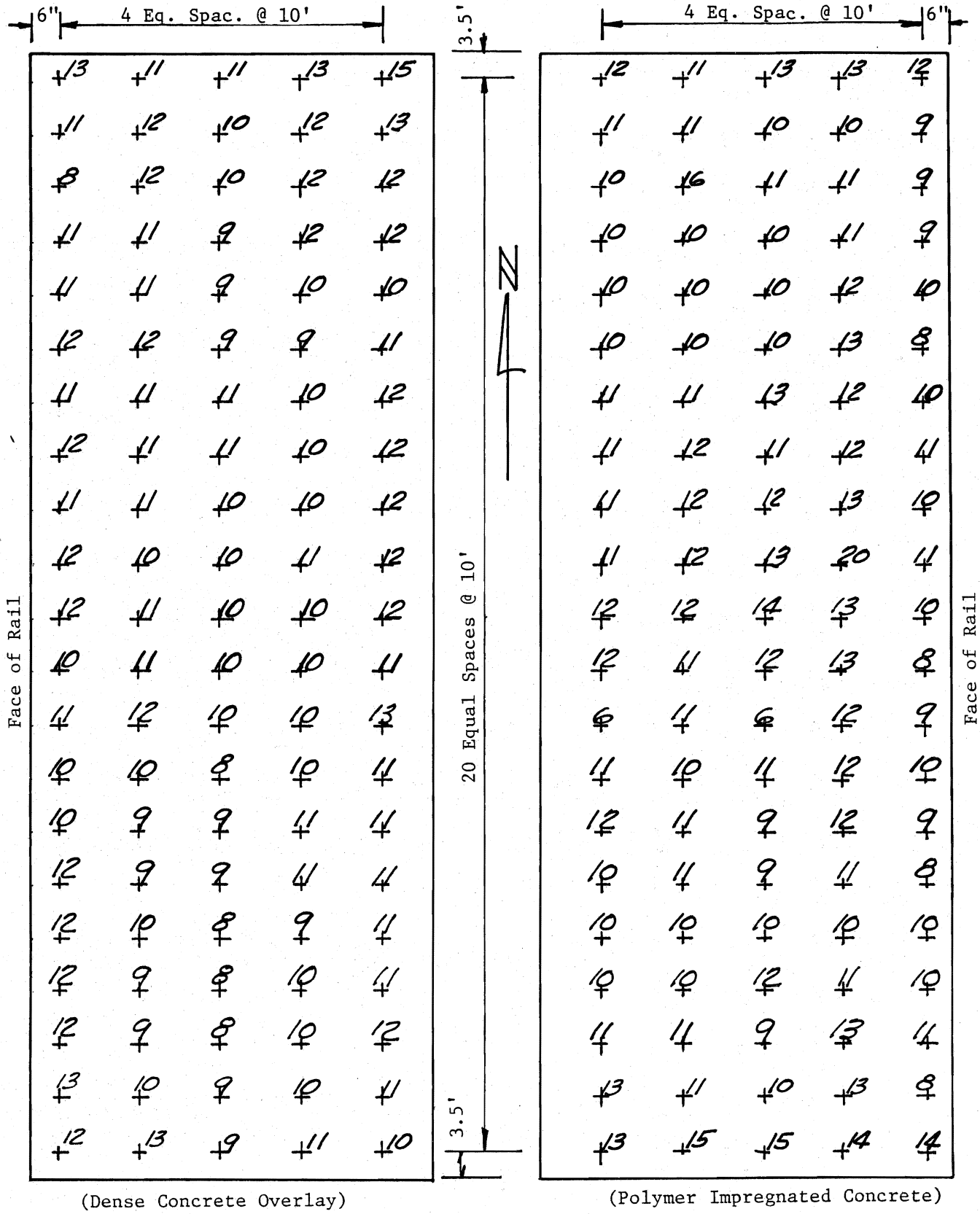
4134.11. Payment. Payment for Dense Concrete Overlay will be made at the contract unit price bid per square yard measured as prescribed above. The above payment shall be full compensation

for scarifying and cleaning existing slabs, furnishing, placing, finishing and curing concrete overlay, all tools, labor, equipment and incidentals necessary to complete the work.

Payment for linseed oil application shall be in accordance with the Item, "Concrete Surface Treatment".

APPENDIX C

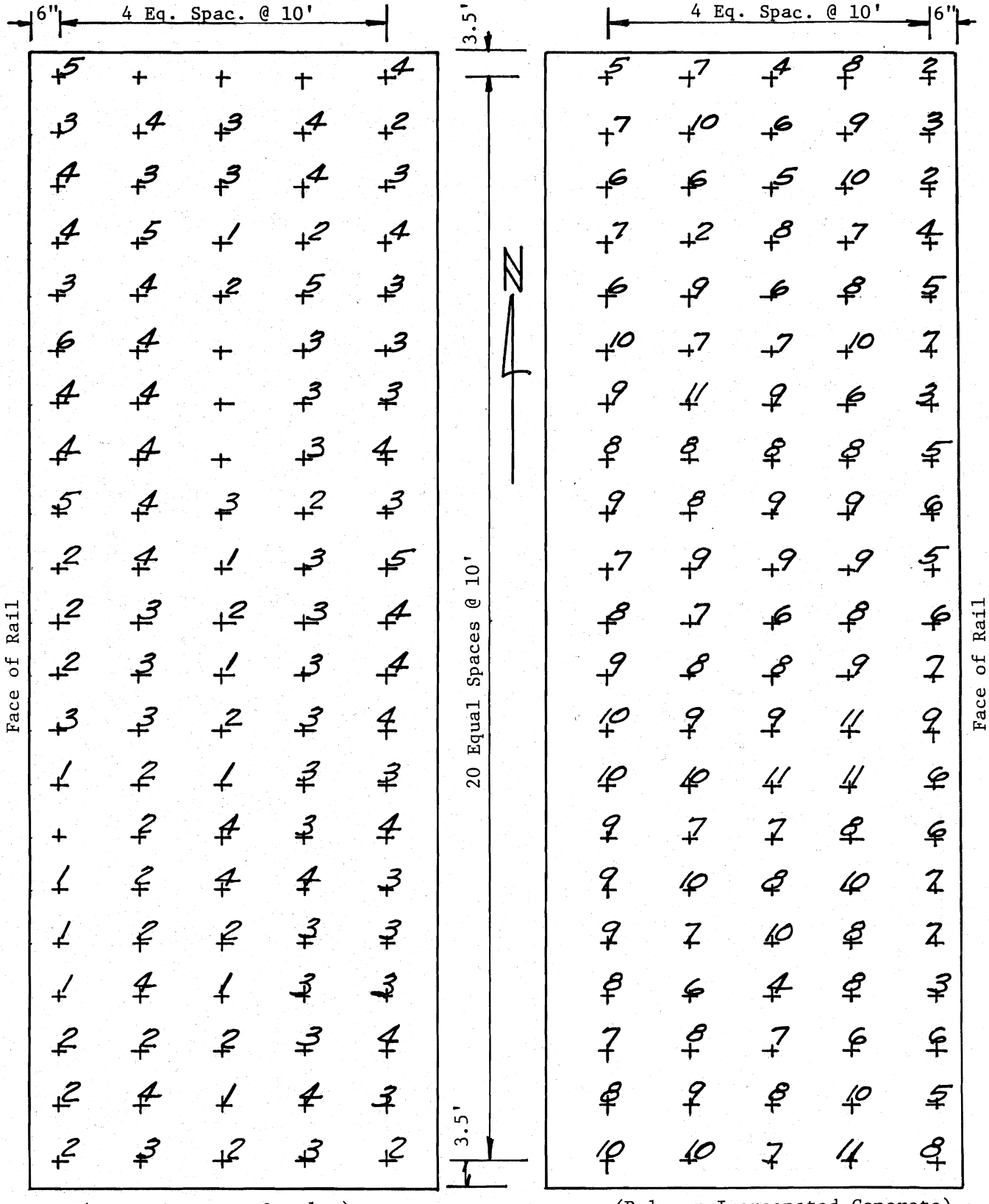
CORROSION POTENTIALS



Corrosion Potential Measurements

IH 27 at County Road 60

Aug. 16, 1978



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(Polymer Impregnated Concrete)

Corrosion Potential Measurements

IH 27 at County Road 60

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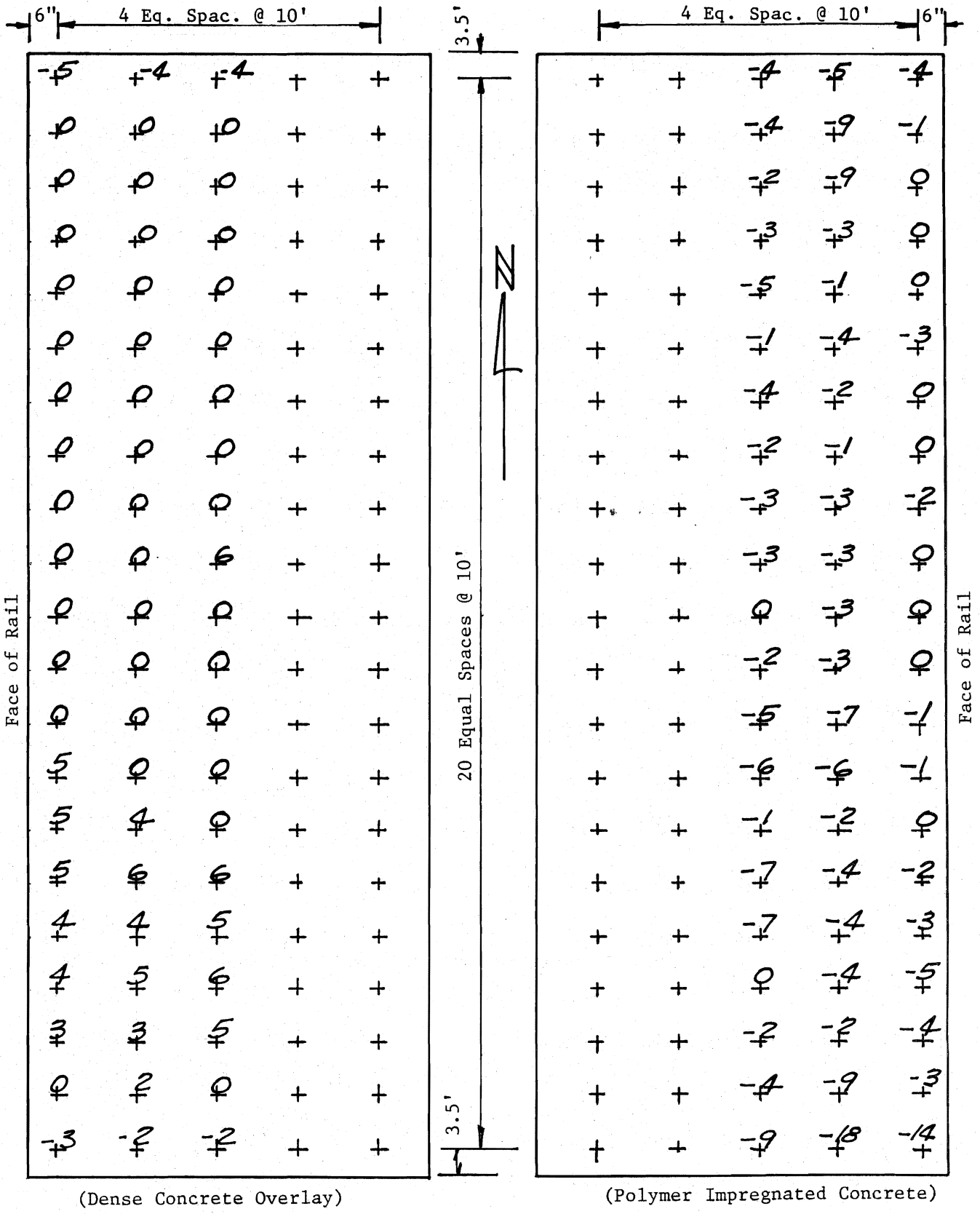

Corrosion Potential Measurements

IH 27 at County Road 60

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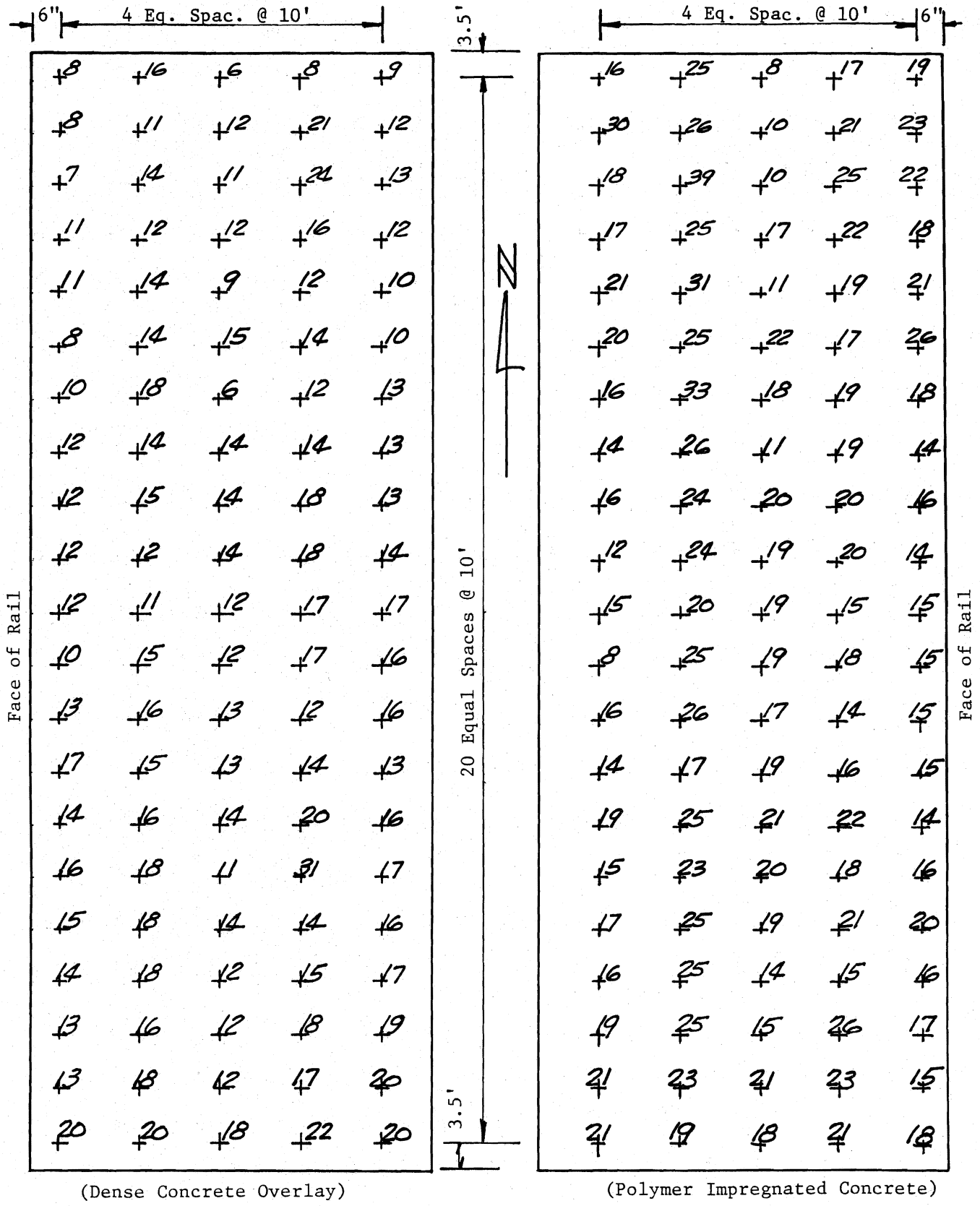


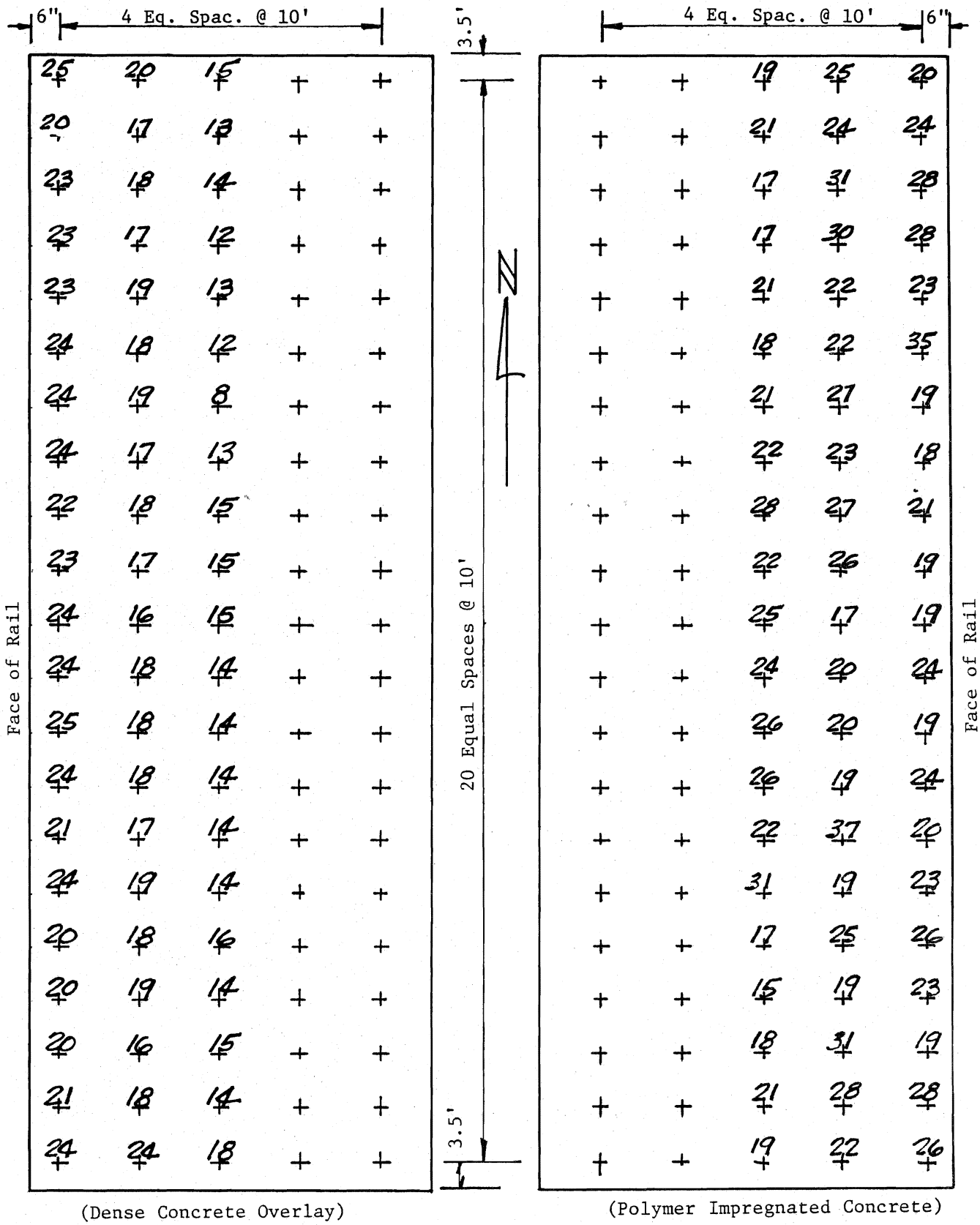
(Dense Concrete Overlay)

(Polymer Impregnated Concrete)

Corrosion Potential Measurements

IH 27 at County Road 60

Aug. 16, 1983



Corrosion Potential Measurements

IH 27 at County Road 60

July 11, 1985