Effectiveness Of Concrete Bridge Deck Asphalt-Membrane Protection

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16. Abstract

This study field tests and evaluates conditions of five bridge decks in Washington rehabilitated and waterproofed by WSDOT System "C" membrane and paved with asphalt concrete overlay. The study also reviews and evaluates the WSDOT's membrane selection criteria. Based on the results obtained, the membrane system was generally effective in preventing chloride intrusion into concrete decks. Deterioration in concrete and corrosion in rebar, however, was detected. The deterioration was concentrated around, in the boundary, and within the rehabilitated areas. Those test sections which satisfied the WSDOT membrane selection criteria for protection of existing bridge decks showed minimum levels of concrete deterioration.

Included in the study are also recommendations regarding rehabilitating, waterproofing, and testing bridge decks as well as selecting bridge decks for membrane waterproofing.

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EFFECTIVENESS OF CONCRETE BRIDGE DECK ASPHALT - MEMBRANE PROTECTION

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DISCLAIMER

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TABLE OF CONTENTS

Section	Page
List of Tables	xi
List of Figures	xiii
EXECUTIVE SUMMARY	xv
CONCLUSIONS AND RECOMMENDATIONS	xviii
CHAPTER I: REVIEW OF BACKGROUND INFORMATION AND EXPERIMENT DESIGN	1
Introduction of Background Information	1
Classification of Candidate Sites Relative to Present WSDOT Membrane Selection Criteria	10
Designation of Test Sites	12
Experiment Design	12
CHAPTER II: DATA ANALYSIS AND INTERPRETATION	15
Condition of AC Overlays	15
Permeability of AC/Membrane System	19
Condition of Reinforced Concrete Bridge Decks	29
Comments on WSDOT Membrane Selection Criteria	41
Comments on the Field Evaluation Techniques	44
REFERENCES	49

TABLE OF CONTENTS (Continued)

Section **Page**

APPENDIX A: BACKGROUND INFORMATION ON CANDIDATE TEST BRIDGES

WSDOT End of Project Report for Contract #1594 (Bridges 90/136 S, 90/140 S, 90/141 S, 90/145 S and N A-1

WSDOT Description of Materials Used for Contracts #1594 and #1481 (Bridges 90/136 S, 90/140 S, 90/141 S, 90/145 S and N, and 82/20 N) A-5

WSDOT Laboratory Tests on Patch Concrete Used for Contracts #1594 and #1481 (Bridges 90/136 S, 90/140 S, 90/141 S, 90/145 S and N, and 82/20 N).. A-11

Location of Rehabilitated Concrete and Results of Pre-Rehabilitation Half-Cell and Chloride Tests on Candidate Test Bridges (Bridges 90/136 S, 90/140 S, 90/141 S, 90/145 S and N, and 82/20 N) A-15

APPENDIX B: DETAILS OF EXPERIMENT DESIGN

APPENDIX C: STUDIES' RAW DATA COLLECTED IN FIELD AND LABORATORY

Collected Data on Bridge 90/136 S C-1

Collected Data on Bridge 90/140 S C-29

Collected Data on Bridge 90/145 N C-53

Collected Data on Bridge 90/145 S C-71

Collected Data on Bridge 82/20 N C-89

LIST OF TABLES

Table		Page
1.	General Information on Candidate Bridges for Test Program	4
2.	Pre-Rehabilitation/Protection Conditions of Candidate Test Bridge Decks Relative to the Present Membrane Selection Criteria	5
3.	Selection of Test Sites	13
4.	Results of Electrical Resistivity Test on Asphalt Overlays	21
5.	Results of Coring for Presence of Moisture Under Membrane	21
6.	Moisture Content of Concrete Decks Covered by AC/membrane System	22
7.	Resamples of Pre-rehabilitation/Waterproofing of Chloride Tests	23
8.	Post-rehabilitation/Waterproofing Chloride Content of Patch Concrete	23
9.	Correlation of Ranked Half-Cell Readings with Delaminations for Each Tested Bridge Deck	37
10.	Classification of Half-Cell Readings on Each Bridge and Comparison with Concrete Deterioration	38
11.	Overall Correlation of Ranked Half-Cell Readings with Delaminations	46
B-1.	Layout of Core Locations	B-2

LIST OF FIGURES

Figure		Page
1.	Location of Candidate Test Bridges	2
2.	Local Pattern Cracking in AC Caused by Underlying Concrete Deterioration	16
3.	Stripped Aggregate in the Bottom of AC in a Core Location in the Cracked Overlay (Bridge 82/20 N)	16
4.	Stripped AC Caused by Defects in the Bottom of the Overlay	17
5.	AC Deterioration in the Vicinity of Abutment Joint	18
6.	Present Condition of an Elastomeric Expansion Device and Asphalt Overlay Paved Next to It	18
7.	Concrete Delamination (Patch) Under Sound AC Overlay and Membrane	31
8.	Severe Disintegration of Concrete (Patch) Associated with Pattern Cracking of AC	31
9.	Concrete Delamination (Original) Around a Patch Area	32
10.	Concrete Delamination (Half Patch, Half Original) in the Boundary of a Patched Area	32
11.	Delamination of Patched Concrete	33
12.	Severe Cracking of AC and Disintegration of Patched Concrete. Note the Conical Shaped Patched Material Left in the Core Location After Drilling Through Concrete.	33
13.	Superimposing Rehabilitated Areas and Defective Areas Indicated by Chain Dragging, Bridge 90/136 S	34
14.	Superimposing Rehabilitated Areas and Defective Areas Indicated by Chain Dragging, Bridge 90/140 S	35
15.	Superimposing Rehabilitated Areas and Defective Areas Indicated by Chain Dragging, Bridge 90/145 N	36
B-1.	Data Form for Ground	B-4
B-2.	Data Form for Coring Operation	B-5

EXECUTIVE SUMMARY

Asphalt/membrane protection of bridge decks, generally applied after rehabilitating damaged decks with fast setting concrete, has been used extensively in the past in Washington and continues to play a role in protecting bridge decks from the corrosive effects of salts. Previous TRAC/WSDOT bridge deck membrane research evaluated the condition of three concrete decks covered by membrane systems adopted in the past. That work cast doubts on the effectiveness of those systems by revealing deterioration beneath the asphalt overlay and around the rehabilitated areas. Subsequently, WSDOT developed criteria for asphalt/membrane protection which limited its application to certain bridge conditions. The research discussed here supplements the previous research by evaluating the effectiveness of a better quality membrane system more widely used at present, i.e., the WSDOT System "C" membrane, or hot applied rubberized asphalt protected with fabric.

STATE OF ASPHALT OVERLAYS

Five bridges were included in the study, four on SR-90 and one on SR-82. The asphalt overlays were generally in fair condition after six years of service. The major damage to the overlays was in the form of pattern cracking (interconnecting cracks) caused by either concrete deterioration or aggregate stripping in the bottom portion of the overlay. The latter problem, which ultimately resulted in stripping of the overlay, was caused by water accumulation on the top of the membrane. Increasing the impermeability of the overlay by decreasing the air voids in the system, possibly by more effectively compacting the overlay, and incorporating effective anti-stripping agents into the overlay mix might alleviate the problem.

SYSTEM PERMEABILITY

The asphalt overlay/membrane system was effective in preventing chloride intrusion into the concrete, although spot chloride leakage was detected. The moisture content of the concrete, however, was relatively high, and its origin could not be positively determined. Moisture in concrete might have penetrated through the membrane, from the environment, or it might have existed in the decks when they were waterproofed. However, evidence of moisture under the membrane in a few locations suggested that the installations were capable of water seepage in some areas. Vapor transmission through the membrane may not be possible, resulting in the moisture being trapped in the concrete. To provide a more waterproof membrane the writer recommends avoiding the use of crushed aggregate in the bottom layer of the asphalt overlay to avoid possible puncture of the membrane. An alternative may be to use a fine-graded mix such as WSDOT class "G" asphalt concrete in the bottom portion of the overlay or protection boards under the overlay.

STATE OF UNDERLYING REINFORCED CONCRETE DECKS

Generally, the condition of the concrete decks was not satisfactory. Concrete deterioration was found around, in the boundary of, and within the patched areas. Defects in the concrete ranged from simple delaminations to extensive disintegration associated with asphalt overlay cracking. The latter was mainly detected in the patched concrete. Visual inspection of cored patched concrete suggested that its inferior quality had contributed to its extensive disintegration. Deteriorated concrete generally showed high half-cell potentials, indicating the role of rebar corrosion in the deterioration. Deteriorated concrete also coincided with wheel paths, indicating the contribution of fatigue stress to the deterioration. In order to alleviate deterioration in patch material, requirements on its strength, durability, and fatigue properties comparable to those for portland cement concrete are needed.

The pH and alkalinity of patch concrete also need to be taken into consideration to prevent corrosion of rebar embedded in the patch, in view of the moisture present in the underlying decks. Another alternative could be epoxy coating the exposed rebar during rehabilitation, which can prevent corrosion in the patched areas and reduce its intensity in the surrounding original concrete.

EFFECTIVENESS OF WSDOT MEMBRANE CRITERIA

Among the test sites, those with minimum areas of rehabilitation and original chloride contamination, in compliance with the present WSDOT membrane selection criteria (see page 10 for the criteria), showed a minimum of concrete deterioration and rebar corrosion, indicating the effectiveness of the criteria. The requirement for minimum concrete cover thickness in the criteria, however, should perhaps be increased since rigid overlays are not applied. Further experience should also be used to establish more accurate quantitative criteria.

CONDITION EVALUATION METHODS

Chain dragging on the asphalt concrete and half-cell corrosion detection through the asphalt and membrane both proved to be effective tools in determining the condition of the underlying reinforced concrete decks. Mapping the patched areas during rehabilitation is strongly suggested in order to better understand possible future deterioration under the asphalt concrete if distress is detected.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The following conclusions appear warranted based on the discussions presented in the corresponding sections in Chapter II.

CONDITION OF AC OVERLAYS

- The AC overlays were generally in fair condition after six years of service. The major damage to the overlays was in the form of pattern cracking caused by either underlying concrete disintegration or aggregate stripping in the bottom portion of AC.

PERMEABILITY OF AC/MEMBRANE SYSTEMS

- The AC/membrane systems have been effective in preventing chloride intrusion into the concrete, although spot chloride leakage was detected. Moisture, however, was present (varying from 1.8 to 4.8 percent by weight of concrete with an average of 3 percent) and its origin could not be positively determined. Evidence of moisture between the membrane and the concrete observed in a few core locations suggested that the installations were capable of permitting water seepage in some areas.

CONDITION OF UNDERLYING CONCRETE DECKS

- Generally, the condition of the underlying concrete decks was not satisfactory. Concrete deterioration was detected around, in the boundary of, and within the patched areas. Defects in the concrete were found in the forms of delamination under sound AC and severe disintegration, causing pattern cracking in the AC. The latter was mainly detected in patched concrete. Visual inspection of the cored patched concrete suggested that its inferior quality contributed to its extensive disintegration.

- Deteriorated concrete generally showed high half-cell potentials, indicating the role of rebar corrosion in the deterioration. Deteriorated concrete also coincided with wheel paths, indicating the contribution of fatigue stress to the deterioration.

MEMBRANE APPLICATION CRITERIA

- Among the test lanes, those with a minor amount of rehabilitation and original chloride contamination, in compliance with the present WSDOT membrane selection criteria (see page 10 for the criteria), showed the least amount of concrete deterioration.

FIELD EVALUATION TECHNIQUES

- Chain dragging AC detected deterioration in the underlying concrete and in the bottom portion of the AC without delineating the type of the deterioration. The writer believes that the ratio between the detected deterioration in concrete and the total deterioration in concrete depends on the severity of the deterioration.
- An excellent correlation was found between high half-cell potentials and concrete deterioration. The correlation is probably due to active corrosion occurring at the time of the tests due to the presence of moisture in the concrete.

RECOMMENDATIONS

Based on the discussions presented in the corresponding sections in Chapter II, the following measures are recommended for improving and enhancing future work if the measures are different from the Department's current policies:

IMPROVE THE QUALITY OF THE AC/OVERLAY BY:

- compacting the overlay more effectively, possibly by applying pneumatic compactors, to provide a denser mix and to increase the AC's impermeability,
- avoiding weak seams in AC construction joints and their coincidence with wheel paths;
- incorporating effective anti-stripping agents into the overlay mix.

IMPROVE THE IMPERMEABILITY OF THE MEMBRANE BY:

- avoiding the use of crushed aggregate in the bottom layer of the AC overlay and instead using a type of aggregate and gradation which can act as a cushion; WSDOT class "G" mix (fine graded) may be suitable for this purpose. Another alternative may be use of protection boards under the AC overlay as practiced in Ontario;
- specifying a minimum thickness for the membrane system such as 1/8-inch (3 mm) (depending on grade and super elevation) and incorporating practical methods of inspecting membrane thickness and quality during installation.

IMPROVE THE QUALITY OF PATCH AND CORROSION RESISTANCE BY:

- specifying strength, durability, and fatigue properties for the patch concrete so they will be comparable to those of the portland cement concrete. Test procedures need to be established to determine durability under freeze-thaw and fatigue under compression for this purpose;
- specifying pH values for the patch concrete so they will be comparable to those of the portland cement concrete to prevent corrosion in the patched area.

MODIFY THE MEMBRANE CRITERIA (SEE PAGE 10) BY:

- requiring a thicker concrete cover for AC/membrane applications on existing decks, such as 90 percent of the deck area with a concrete cover thicker than 1 in. (2.54 cm) and 50 percent of the deck area with a concrete cover thickness not less than 1.5 in. (3.81 cm);
- incorporating future experience to establish more accurate criteria quantitatively.

IMPROVE FIELD EVALUATION METHODOLOGY BY:

- mapping patched areas on the bridge decks at the time of rehabilitation and superimposing such data with deterioration detected by chain dragging the AC to better understand the nature of problem. If there are doubts over the origin of the problem, dry coring the AC at a few locations and sounding the concrete in core locations can distinguish the deterioration in concrete from that in AC.

CHAPTER I

REVIEW OF BACKGROUND INFORMATION AND EXPERIMENT DESIGN

This chapter is a digest of the background information pertinent to the six bridges chosen as candidates for evaluating the effectiveness of patching and waterproofing with the AC/membrane system. (After reviewing the information, five sites were selected for the experiment, as originally proposed.) Included in this chapter is also a comprehensive program designed for testing the selected sites in conjunction with the WSDOT Materials Laboratory.

The background information comprises data collected from the WSDOT's Bridge and Structures Branch, Materials Laboratory and District 5. Generally, the information includes pertinent data on the original design of the decks and on rehabilitation performed on the concrete.

After the information was reviewed, it was summarized, tabulated and plotted so that it could be evaluated. Subsequently, an experiment was designed to fit the conditions of the test sites.

INTRODUCTION OF BACKGROUND INFORMATION

The six candidate bridges are listed below, and their location can be found in Figure 1.

1. Bridge 90/136 S (S. Cle Elum RD OC)
2. Bridge 90/140 S (Yakima River)
3. Bridge 90/141 S (CMTPP RR PEOH RD OC)
4. Bridge 90/145 N (Highline Canal)
5. Bridge 90/145 S (Highline Canal)
6. Bridge 82/20 N (Squaw CR RD OC).

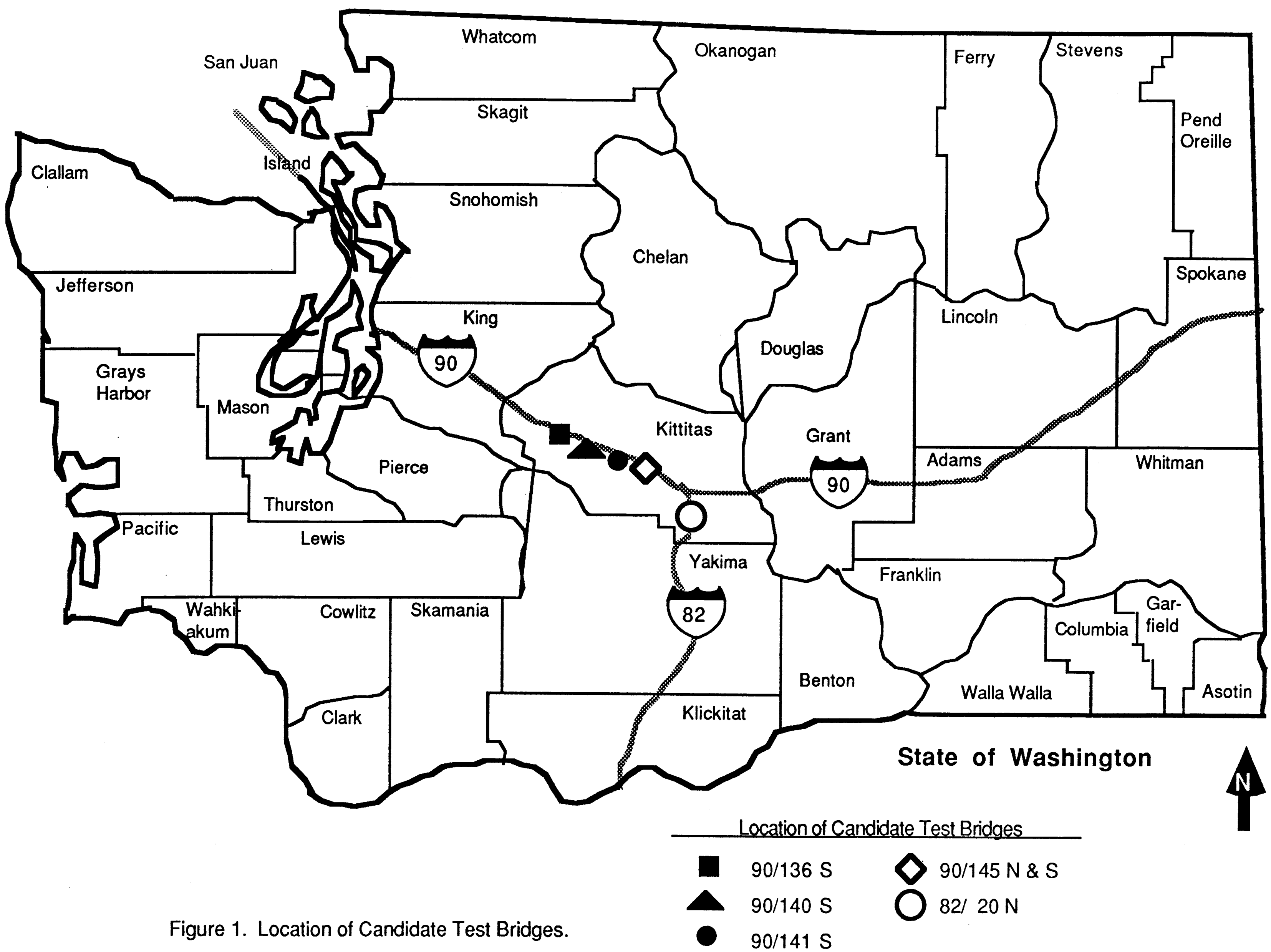


Figure 1. Location of Candidate Test Bridges.

Some information on the candidate sites, such as type of structure, properties of decks, year of original construction and rehabilitation, are tabulated in Table 1.

REPAIR HISTORY (SR 90 BRIDGES) (DIGESTED FROM CONSTRUCTION PROJECT DIARY AND OTHER SOURCES)

Bridges 90/136 S, 90/140 S, 90/141 S, and 90/145 N and S were all repaired and waterproofed under Contract 1594 in the summer of 1979. At that time the bridges were about 14 years old. The project had been originally scheduled for 1980. However, rapid deterioration of the decks made it necessary to advance the project to 1979. In 1978 WSDOT estimated the concrete repair that would be needed based on a delamination survey (see Table 2 for extent of deterioration) and applied a multiplier of 2. However, the actual volume of repair in 1979 overran the estimated quantity by 25 percent, 2.5 times what the 1978 delamination survey had detected. Larger and deeper amounts of deterioration contributed to this occurrence.

Concrete Removal and Repair. Deteriorated concrete detected by chain dragging was removed by jack hammers. Because of concerns over removing concrete in negative movement areas around the interior piers of continuous structures, crews considered concrete removal from only 1/2 of a lane width for 15' (3.8m) on one side of each pier at a time. Deep deterioration had rarely occurred. Generally, removal exceeding mid-depth of a slab was not advised.

The contractor used Jet Set Super X, a prepackaged, fast setting concrete, for repairing the concrete. Because of its relatively higher initial set period of about 15 minutes, the concrete was well suited to repairing large areas, resulting in better consolidation, better finishing of the concrete, and the elimination of cold joints between succeeding repair sections. The patching material had to meet 3,000 psi (21 mpa) compressive strength in 6 hours as tested in 2 inch (5.1 cm) cubes. Some test data from cubes made of a patch placed in the project site showed that after 6 hours the

Table 1. General Information on Candidate Bridges for Test Program.

Bridge No. and Name	Year Built	Type	Skew	Grade	Length	Roadway Width	Deck Slab Thickness	Deck Top Trans. Rebar	Deck Nominal Conc. Cover	Year * Rehabilitation and Waterproofed	ADT (1983)	Rating
90/136 S S. Cle Elum Rd OC	1966	5-span concrete box girder (continuous)	0°	-2.13%	424.5'	30'	7 1/4"	#6	1 1/2"	1979	5,874	H-20
90/140 S Yakima River	1965	5-span concrete box girder (continuous)	0°	-0.658%	390'	30'	6 1/2"	#5	1 1/2"	1979	5,874	H-20
90/141 S CMSTPP RR Peoh Rd OC	1965	4-span prestressed concrete beams (partially continuous)	53° 52' 30"	V.C. +4.00% -1.60%	374.58'	30'	5 3/4"	#5	1 1/2"	1979	5,874	H-20
90/145 N Highline Canal	1965	2-span prestressed concrete beams (simple)	46° 18'	V.C. +5.00% +3.00%	175.25'	36.5'	5 3/4"	#5	1 1/2"	1979	6,012	H-20
90/145 S Highline Canal	1965	2-span prestressed concrete beams (simple)	46° 18"	+4.00%	179.25'	36.5'	5 3/4"	#5	1 1/2"	1979	5,874	H-20
82/20 N Squaw Cr Rd OC	1971	3-span prestressed conc. beams (partially continuous)	5° 31' 23"	V.C. -1.20% -3.40%	141.58'	38'	7"	#6	1 1/2"	1979	3,792	HS-20

* After removing deteriorated concrete and patching, decks were waterproofed with applied-in-place rubberized asphalt membrane (system "C" of WSDOT) and overlaid with 1.8" nominal thickness AC (1.5" for bridge 82/20 N).

Table 2. Pre-rehabilitation/Protection Conditions of Candidate Test Bridge Decks Relative to thePresent Membrane Selection Criteria.

Bridge Number	Extent of Deterioration* (% of deck area)			Concrete Cover >1" (% of deck area)	ADT**	c1>2#/cy + (% of samples tested)			Surface Compatibility	
	<5%<	P	D	<90%<	<10,000<	<40%<	P	D	yes	no
90/136 S	11%	5%	17%	- -	5,874	80%	67%	100%	X	
90/140 S	7%	6%	7%	- -	5,874	73%	63%	86%	X	
90/141 S	4%	2%	7%	- -	5,874	60%	57%	75%	X	
90/145 N	4%	0%	7%	- -	6,012	50%	25%	75%	X	
90/145 S	5%	0%	8%	- -	5,874	25%	0%	60%	X	
82/20 N	8%	14%	3%	- -	3,792	100%	100%	100%	X	

* Surveyed one year prior to reconstruction in 1978

** Surveyed in 1983

\+ Sampled shortly prior to reconstruction and generally at 1-1/2" to 2" depth

[shaded box] Criteria Zone

P Passing lane

D Driving lane

patch's strength was 2,400±psi (17±mpa). This was lower than expected and was speculated to be the result of prematurely applying the curing cover to the patch. Results from further tests conducted by the WSDOT Materials Laboratory on the repair material sampled from the job site indicated that an average strength of 4,425 psi (31 mpa) and 5,017 psi (35 mpa) could be gained in 6 and 24 hours, respectively (see Appendix A). These tests also indicated that original chlorides did not exist in the repair concrete (i.e., cl content = 0 percent).

A cover thickness of less than 1 in. (2.54 cm) in the new patches was not desired. Therefore, the patches had to be mounded to achieve a 1 in. (2.54 cm) cover where the existing cover thickness was insufficient.

A significant loss of edge bond between the repair concrete and the original concrete occurred after patching despite all the care that was taken during the repair, such as sawing the perimeter of the area and cleaning the substrate. There was often obvious shrinkage cracking and delaminations, as evidenced through chain dragging. Some cores taken from these areas during construction broke between the new and old concrete while they were being chiseled out. According to the manufacturer's description the patch material will not shrink while curing but instead, will show a slight expansion at the end of 28 days. In the writer's opinion the loss of edge bond may have been the result of expansion and contraction caused by thermal cycling. However, no information pertaining to the material's coefficient of thermal expansion and modulus of elasticity is available to define the thermally-induced shear bond. The resident engineer also speculated that local vibration in the structure due to passing traffic might have caused the problem. The loose patches were removed and repaired.

AC/Membrane Application. The waterproofing membrane system was WSDOT system "C". The rubberized asphalt contained AR4000W asphalt binder with G-274 type rubber and Califlux extender oil. The polypropylene fabric used over the rubberized asphalt membrane for its protection was Petromat. WSDOT class "B" asphalt concrete was paved over the membrane system with a nominal thickness of 1.8 in. (4.57 cm) (see Appendix A for more information regarding the materials used).

REPAIR HISTORY (SR 82 BRIDGE) (DIGESTED FROM CONSTRUCTION PROJECT DIARY AND OTHER SOURCES)

Bridge 82/20 N was rehabilitated and waterproofed along with two other bridges on SR 82 (82/25 N and S) under contract 1481 in 1979. At the time of rehabilitation the bridge was about 8 years old. The project work on bridge 82/20 N started in May and was completed in July. A delamination survey made in May of 1978 indicated that about 8 percent of the total deck area had deteriorated. Additional deterioration, however, was found during rehabilitation.

Concrete Removal and Repair. Deteriorated concrete located by chain dragging was removed by jackhammers. The exposed rebar exhibited rust and the surfaces of some bars were slightly pitted. In places where it was not certain that deeper deterioration had occurred, crews did not remove concrete below about the mid-depth of the slab. Tests with a Swiss hammer in some areas of questionable concrete integrity indicated the concrete's strength to be about 4,000 psi (28 mpa).

Set-45, a prepackaged, fast-setting concrete, was used for repairing the concrete. Tests conducted by the Materials Laboratory on the repair material sampled at the job site indicated that a compressive strength of 10,225 psi (71 mpa) and 10,363 psi (71 mpa) could be reached in 6 and 24 hours, respectively (see Appendix A). No test results were available on the original chloride content of the patch material. The patch material, because of its relatively faster initial set period at high temperatures, was not well suited to repairing large areas. This resulted in the development of cold joints in the repair area. In some batches ice was used to retard the initial set time. To eliminate cold joints, the manufacturer recommended using larger batches in a larger, mobile mixer located at the patch area.

Loose patches were found in many areas after placement and hardening. One reason for the patch failure was believed to be the lack of a sufficient quantity mortar in the mixture, which was not able to thoroughly coat the surface of the old concrete. With insufficient mortar the aggregate could bridge a small portion of the patch and prevent the mortar from filling the voids. No bonding agent on the surface of the concrete was required with this type of repair material. The resident engineer observed that the amount of rock in the mix could be reduced from 30 lb (14 kg) to 20 lb (9 kg) per bag of Set-45 to coat the surface of the area to be patched. Heat built up in the patch concrete during the curing period was also thought to cause thermal contraction, which in turn could have caused the problem experienced, especially in large patches. Keeping the patch cool during the curing period was thought to be effective for alleviating the problem. The patches, where they were loose and debonded, were removed and repaired with the same material.

Fondu fast-setting cement, due to its reputation for a slower initial set period, was applied experimentally on some areas. The general conclusions were that the material's strength gain was slower and that its characteristics were sensitive to its water content. Based on tests conducted during different trials, in 6 hours the patch's strength was 3,000± psi (21± mpa). No test results were available on the original chloride content of the mixture. However, the chemical analysis of Fondu cement as given in a technical bulletin prepared by the manufacturer does not show any chlorides. Some small Fondu patches also became loose after placement and were removed and repaired with the same material.

AC/Membrane Application. A WSDOT System "C" waterproofing membrane was applied over the repaired deck. The rubber additive for membrane waterproofing was

Atlas. The protective polypropylene fabric used over the rubberized asphalt membrane was Petromat. WSDOT Class "B" asphalt concrete was paved over the waterproofing system with a nominal thickness of 1.5 in. (3.81 cm) (see Appendix A for more information regarding the material used).

PRE- AND POST-REHABILITATION/PROTECTION CONDITION SURVEY DATA (SR 90 BRIDGES)

The following data were collected:

- the results of a delamination survey conducted by District 5 in September 1978 about one year prior to construction (see Table 2 for "Extent of Deterioration of Deck Area");
- the results of a half-cell and chloride survey conducted by the Materials Laboratory in June 1979, shortly before the construction (data is plotted and included in Appendix A for five bridges);
- the locations of rehabilitated areas in concrete decks mapped by District 5 in the summer of 1979 shortly after the rehabilitation (data is plotted and included in Appendix A for five bridges); and
- the results of electrical resistivity testing conducted by District 5 on asphalt concrete in August and September 1979, shortly after the construction; the resistivity values were all higher than 500,000 ohms, indicating an impermeable system at the time of the testing (on a grid of 8 feet by 5 feet all of the readings showed infinity except for two readings on Bridge 90/145 N which showed 600,000 ohms).

PRE- AND POST-REHABILITATION/PROTECTION CONDITION SURVEY DATA (SR 82 BRIDGE)

The following data were collected on the SR 82 bridge:

- the results of a delamination survey conducted by District 5 in May 1978, prior to the construction (data is plotted and included in Appendix A under "Location of Rehabilitated Concrete");
- the results of a half-cell and chloride survey conducted by the Materials Laboratory in June 1979 shortly before the construction (data are plotted and included in Appendix A); and
- the results of electrical resistivity testing conducted by District 5 on asphalt concrete in July 1979 shortly after construction; the resistivity values were all higher than 500,000 ohms, indicating an impermeable system at the time of testing (on a grid of 8 feet by 5 feet all of the readings showed infinity except for one reading which showed 1,000,000 ohms).

CLASSIFICATION OF CANDIDATE SITES RELATIVE TO PRESENT WSDOT MEMBRANE SELECTION CRITERION

In WSDOT's present membrane selection process, an asphalt concrete with a membrane system may be used when all of the following criteria are met:

1. Delaminated and patched areas of the deck are less than five percent of the deck area.
2. Concrete cover exceeds 1 in. (2.54 cm) over 90 percent or more of the deck area.
3. ADT is less than 10,000 and the traffic index is less than 7.5.
4. Chloride contamination at the rebar level is less than 2 lb/cy (1.18 kg/m^3) or exceeds it for less than 40 percent of the samples tested.

5. The deck surface must be compatible with the membrane system. A rough or pocked surface will result in damage to or early failure of the protective membrane.

Information on the above criteria and the pertinent information on the six candidate bridges are given in Table 2. In the following pages, the pre-rehabilitation condition of each deck relative to each criterion is discussed.

EXTENT OF DETERIORATION

As shown in Table 2, three decks satisfied the criteria for deterioration (i.e., deterioration ≤ 5 percent of deck area) and three exceeded that. However, certain lanes in the structures satisfied the criteria regardless of their total deck deterioration. Note that the delaminations indicated in Table 2 were surveyed about one year prior to the rehabilitation since it was done to prepare contract documents. The actual rehabilitated areas, illustrated in Appendix A, were approximately twice as large.

CONCRETE COVER THICKNESS

No information on the concrete cover thickness over the rebar was available. However, it was evident from the background information that the depth of rebar in some patch locations was less than 1 in. (2.54 cm) since the crews were advised to mound the patches to achieve a 1 in. (2.54 cm) cover.

AVERAGE DAILY TRAFFIC (ADT)

As given in Table 2, all of the sites satisfied this criterion. The ADTs given in the table, however, are from 1983 and thus are probably higher than those of 1979, the year of the rehabilitation.

CHLORIDE CONTAMINATION

Only one deck satisfied this criterion. Five other decks exceeded the criterion but at different levels. However, certain lanes in two structures satisfied the criterion, as shown in Table 2. Note that chloride samples were generally obtained at a depth of 1-1/2" - 2" (3.81 cm - 5.08 cm) in the concrete since the depth of the rebar was not determined at the time.

SURFACE COMPATIBILITY

All of the decks should have satisfied the above requirement since the concrete removal areas were thoroughly patched and the patches were smoothed.

DESIGNATION OF TEST SITES

Since the current study proposed testing five bridges, with one lane to be surveyed on a single bridge, one candidate test site needed to be deleted. After a field trip to the six bridges on April 1, 1985, and careful examination of the past and present conditions of the structures, the sites given in Table 3 were selected for the testing program.

The test sites were selected so that they would represent a variety of conditions at the time of rehabilitation relative to the extent of chloride contamination and deterioration, WSDOT's two major membrane selection criteria. This may be noted in Table 3, where the conditions of the test sites are explained.

EXPERIMENT DESIGN

The following tests were performed on each test site (details of the experiment design can be found in Appendix B).

TABLE 3. SELECTION OF TEST SITES

Bridge Number	Test Site	General Condition at the Time of Reconstruction and at the Present*
90/136 S	Passing Lane	Previously, contamination and deterioration exceeding the criteria but not as much as the driving lane. Present condition of AC is satisfactory.
90/140 S	Passing Lane	Previously, contamination and deterioration exceeding the criteria and about the same as the driving lane. Present condition includes cracking in AC in both lanes.
90/145 N	Driving Lane	Previously, contamination and deterioration exceeding the criteria and much more than those of the passing lane. Present condition includes pattern cracking in AC but not in the passing lane.
90/145 S	Passing Lane	Previously, contamination and deterioration satisfying the criteria and much less than those of the driving lane. Present condition of AC is satisfactory.
82/20 N	Driving Lane	Previously, contamination exceeding the criteria. Deterioration at the time of reconstruction not known but probably around the criteria break line. Present condition of AC is debonded and pattern cracked in some locations.

*See Appendix A for detailed information at the time of reconstruction.

1. Visual inspection of the AC for surface distress,
2. Chain dragging the AC to find possible delaminations or debonding,
3. Electrical resistivity of the AC/membrane to find impermeability of the system,
4. Dry coring and removing AC/membrane in order to conduct the following tests (core locations were chosen to coincide with the rehabilitated areas and original concrete as well):
    a. Determination of bonding and waterproofing properties of the AC/membrane system,
    b. Conducting half-cell tests on the exposed concrete to find corrosion,
    c. Conducting a pachometer survey and measuring the depths of the rebar from the concrete surface,
    d. Visually inspecting and sounding the exposed concrete for distress,
    e. Further coring the concrete and inspecting the cored sample for any distress,
5. Determining the water content of the concrete,
6. Chloride content determination in the areas of pre-rehabilitation testing and rehabilitated concrete as well.

CHAPTER II

DATA ANALYSIS AND INTERPRETATION

Chapter II describes the analysis and interpretation of field and laboratory data collected from the five concrete bridge decks rehabilitated and covered with AC/membrane systems. The testing generally followed the plan developed in Chapter I and was conducted by the WSDOT Materials Laboratory. The raw data for each bridge as obtained in the field and laboratory are included in Appendix C.

CONDITION OF AC OVERLAYS

After six years of service, the AC overlays on the test lanes of the five bridges evaluated were generally in fair condition. Visual inspection detected local pattern cracking on bridges 82/20 N, 90/145 N, and 90/136 S, all in the wheel path areas (see Figure 2). A few longitudinal cracks were also detected on the decks. On Bridge 90/140 S, a concentration of transverse cracks of about 4 ft. (1.22m) long was visible around a pier in the wheel path area.

Chain dragging and subsequent coring revealed defects (stripped aggregate) in the AC in the vicinity of the interface, mainly on Bridge 82/20 N, but also on Bridge 90/140 S (see Figure 3). This problem had occurred in the wheel paths and resulted in pattern cracking on the AC surface in some areas. On Bridge 82/20 N it had ultimately caused stripping of the AC in one location (see Figure 4). The pattern cracking of the AC on the bridge decks was also caused by spalling and disintegration of the underlying concrete. The latter is discussed under "Condition of Reinforced Concrete Bridge Decks" in Chapter II.

The average thickness of the AC/membrane system was 1.83 in. (4.6 cm) (90/136 S), 2.11 in. (5.4 cm) (90/140 S), 2.07 in. (5.3 cm) (90/145 N), 2.45 in. (6.2 cm) (90/145 S), and 1.91 in. (4.9 cm) (82/20 N) on the test lanes.

Figure 2. Local Pattern Cracking in AC Caused by Underlying Concrete Deterioration.

Figure 3. Stripped Aggregate in the Bottom of AC in a Core Location in the Cracked Overlay (Bridge 82/20 N).

Pavements on the joints covered with asphalt overlay were generally cracked (see Figure 5). Damage to the asphalt overlay was minimal when paved next to an elastomeric expansion device (see Figure 6).

DISCUSSION

Chain dragging the AC in conjunction with a coring operation detected defects in the AC in the vicinity of the interface. Where the problem had occurred, the coring clearly revealed that the asphalt binder in the bottom layer of the AC was completely stripped, resulting in no integrity between the mixture elements or adhesion between them and the membrane. This phenomenon resulted in the presence of pattern cracking and depression of the AC surface and, ultimately, stripping of the overlay.

Where the problem had occurred on 82/20 N, an AC construction joint had coincided with the wheel path. Under this condition water can easily penetrate into the

Figure 4. Stripped AC Caused by Defects in the Bottom of the Overlay

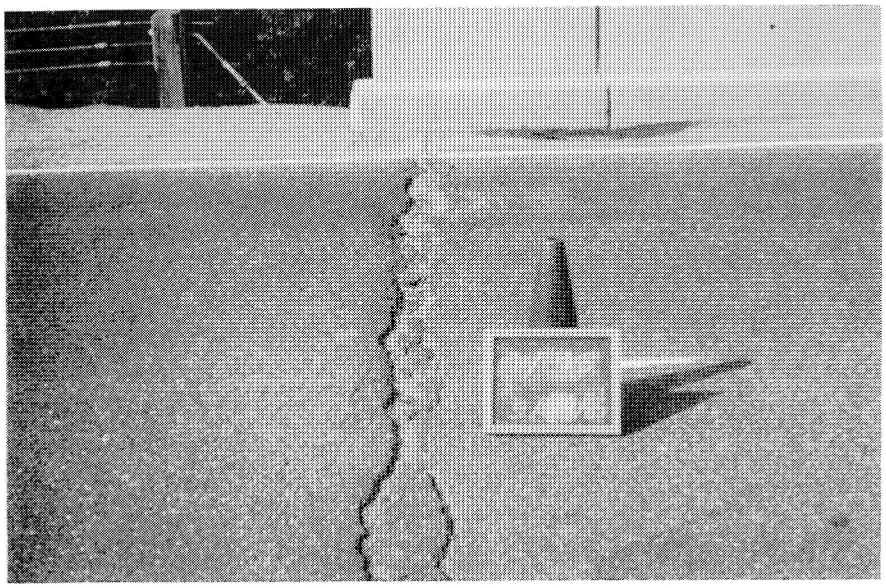


Figure 5. AC Deterioration in the Vicinity of the Abutment Joint.

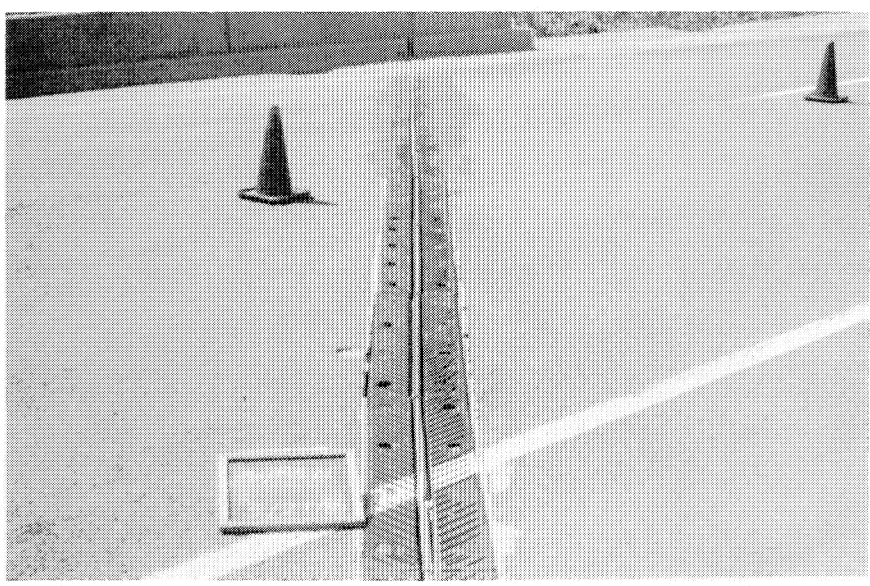


Figure 6. Present Condition of an Elastomeric Expansion Device and Asphalt Overlay Paved Next to It.

AC and accumulate above the membrane. Repeated hydraulic pressure exerted by traffic action can then strip the asphalt. However, regardless of the presence of a joint, water can penetrate AC to some extent and accumulate on top of the membrane. This in turn weakens the bottom layer of the overlay. This was confirmed during coring. Most of the approximately 65 AC core samples were easily chiseled out along a plane slightly above the membrane, indicating the existence of a plane of weakness in that depth.

Isolated longitudinal cracking on 90/140 S was found to be limited to the AC. This type of cracking may have been joint cracking caused by a weak seam between adjoining spreads. The cracking was not necessarily associated with defects in the overlay. The transverse cracking detected around a pier of 90/140 S was probably due to the existence of tensile stresses in the overlay present because of live loading and its bond with the deck. A membrane generally prevents the occurrence of transverse reflective cracking originating from the concrete deck (7).

The following measures are believed to be effective in alleviating the problems associated with the AC overlays:

- o compact the overlay more effectively, possibly by applying pneumatic compactors, to provide a denser mix and to increase the AC's impermeability,
- o avoid weak seams in construction joints and their coincidence with wheel paths; and
- o incorporate effective anti-stripping agents into the overlay mixture. Anti-stripping agents are presently used in WSDOT asphalt concrete mixes.

PERMEABILITY OF AC/MEMBRANE SYSTEM

The permeability of the waterproofing system was judged based on the following techniques:

- electrical resistivity tests,
- dry coring and visual inspection,
- measurement of the moisture content of the underlying decks,
- a comparison of pre- and post-waterproofing chloride content

- **Electrical Resistivity Test.** The results of the test are given in Table 4. Most of the waterproofing areas on the decks were defective, based on the generally accepted criteria for the test (resistivity <100,000 ohms is defective, 100,000-500,000 ohms is questionable, and resistivity >500,000 ohms is acceptable). Note that the results of the tests shortly after overlaying were all satisfactory (infinite resistivity).
- **Coring Program.** Dry coring and removal of the AC/membrane system while pre-wetting the AC surface enabled the testing crew to visually detect moisture under the membrane on the concrete surface. The results are summarized in Table 5. Based on these results 25 percent of the total core locations (15 out of 63) on all five bridges showed the presence of some moisture under the membrane. Generally, because of a very small amount of moisture present it was difficult to positively confirm the existence of the dye mixed in the pre-wetting solution. However, in six core locations penetration of dye through the AC and in five core locations penetration of dye through the membrane could be positively confirmed.
- **Moisture Content of Concrete.** The moisture contents of the underlying decks are presented in Table 6. A total of 10 measurements were taken (two measurements for each bridge) from 1/4 in. (0.6 cm) to 1-1/2 in. (3.81 cm) depth. The moisture content ranged from 1.8 percent to 4.8 percent with an average of 3.0 percent.

Table 4. Results of Electrical Resistivity Test on Asphalt Overlays

Bridge No.	Distribution of Electrial Resistivity Readings		
	% Reading <100,000 Ohms	100,000 Ohms <% Reading<500,000 Ohms	% Reading >500,000 Ohms
90/136 S	70	19	11
90/140 S	44	13	43
90/145 N	35	23	42
90/145 S	60	25	15
82/20 N	17	21	62

Table 5. Results of Coring for Presence of Moisture Under Membrane

Bridge No.	Total Number of cores	Cores Showing Moisture Under Membrane	
		Number	% of Total Number
90/136 S	18	6	33
90/140 S	15	4	27
90/145 N	10	1	10
90/145 S	10	0	0
82/20 N	10	5	50
Overall	63	16	25

Table 6. Moisture Content of Concrete Decks
Covered by AC/Membrane System

Bridge No.	Moisture Content Wt% of Dry Concrete		
	First Sample	Second Sample	Average
90/136 S	4.8	2.7	3.8
90/140 S	3.7	1.8	2.8
90/145 N	2.3	2.6	2.5
90/145 S	3.8	3.3	3.6
82/20 N	2.4	2.2	2.3
Total Average			3.0%

o **<u>Chloride Content Comparison.</u>** Chloride content samples in the current study were divided into two groups. The first group included resamples of the pre-rehabilitation chloride test conducted on the concrete which remained in place after rehabilitation. The results of the first group are given in Table 7. The second group included samples from the patch material placed during the rehabilitation. The results of the second group are given in Table 8. The results from the first group indicated an average increase of 1.28 lb/c.y. (0.76 Kg/m^3) for five bridges tested. The increase was found in 47 percent of the samples (10 out of 21). Surprisingly, the remainder of the samples showed some decrease in chloride content, which averaged 1.75 lb/c.y. (1.03 kg/m^3). On the patch material (second group), one sample out of seven had a chloride content of

Table 7. Resamples of Pre-rehabilitation/Waterproofing Chloride Tests

Bridge No.	Total Number of Resamples	Resamples Showing Increase in $\overline{Cl}$		Average Increase in $\overline{Cl}$, lb/c.y.
		Number	% of Total Number	
90/136 S	6	1	16%	1.37
90/140 S	6	3	50%	0.97
90/145 N	3	2	66%	2.35
90/145 S	4	3	75%	0.83
82/20 N	2	1	50%	0.92
Overall	21	10	47%	1.28

Table 8. Post-rehabilitation/Waterproofing Chloride Content of Patch Concrete

Bridge No.	Cl Profile Depth in.	$\overline{Cl}$ lb/c.y., corresponding to depth	
		First Sample	Second Sample
90/136 S	0-½	0.20	
	½-1	0.25	
	1-1½	0.30	
90/140 S	0-½	0.25	0.19
	½-1	0.26	0.24
	1-1½	0.20	0.35
90/145 N	0-½	0.32	
	½-1	0.21	
	1-1½	0.20	2.59
90/145 S	–	–	–
82/20 N	0-½	0.29	0.25
	½-1	0.29	0.36
	1-1½	0.32	0.23
	1½-2	0.12	

2.59 lb/c.y. (1.53 kg/m³) indicating the penetration of a considerable amount of chloride into the concrete. The rest of the samples in the second group, each representing a profile, regardless of location or depth, contained a negligible amount of chloride ranging from 0.12 lb/c.y. (0.07 kg/m³) to 0.36 lb/c.y. (0.21 kg/m³). Note that a chloride test at the time of patching indicated 0 percent chloride for the patch material used on the SR-90 bridges.

DISCUSSION

The results of the electrical resistivity test implied that the installations were not waterproofing relatively large areas of the decks as compared to the satisfactory readings obtained shortly after their installation. Since the one hour waiting period for pre-wetting may not have been quite sufficient, the low resistivity of the circuit obtained may also have been the result of the penetration of the crushed aggregate used in the overlay mix into the membrane under traffic loading. Circuit resistance would naturally be lower when the aggregate particles in the asphalt mix were in contact with the concrete surface. This condition may or may not have provided a permeable membrane since the punctured holes might have been sealed by the presence of the aggregate in the membrane. However, the aggregate itself may have provided a path for moisture and chloride to the concrete. Therefore, preventing this condition would assure an impermeable system. One alternative to achieve this is to avoid using crushed aggregate in the bottom portion of the AC overlay and instead use a type of aggregate and gradation, such as fine grained WSDOT class "G" mix, which may act as a cushion. Another alternative may be the use of protection boards under AC overlay as practiced in Ontario (8).

The moisture under the membrane discovered during the coring operation and through visual inspection is an indication of the system's potential for permeability. The existence of dye in the moisture, however, could only be positively confirmed in a few cases due to a small amount of moisture present. If the presence of the moisture under the membrane was caused by concrete perspiration then it must have occurred uniformly in all the core locations of a particular bridge deck and must not have been limited to a few locations.

The measured moisture content of the underlying concrete decks averaged 3.0 percent, with a maximum of 4.8 percent, which is a relatively high concentration of water in a concrete deck when compared to a presumably waterproofed and dry deck. Note that the concrete could have lost some moisture during the sampling process due to its powdered nature and heat generated by friction between the concrete and rotary hammer used to take the samples. Studies have shown that the moisture content of concretes samples from bare concrete decks generally varies from 0.4 percent (dry condition) to 5.6 percent (wet condition) (1). Studies have also shown that the water absorption of 2 in. (5.1 cm) diameter and 3 in. (7.6 cm) thick conventional concrete specimens after being conditioned in a dessicator, heated, and then soaked in water for 30 days, is in the range of 5.5 percent (2). After one day soaking the absorption was about 4.5 percent and after seven days the concrete had almost reached saturation. Therefore it appears that the average moisture content of the decks (i.e., 3.0 percent) is about 55 percent of the moisture content at the soaked saturation for a conventional concrete. The presence of water in the decks may be explained as follows: moisture can penetrate into the concrete deck from the top through the membrane and from the bottom from the environment. Penetration from the bottom, however, does not occur easily in box girder bridges. It is also possible that moisture existed in the decks while waterproofing them. Although the concrete surface under asphalt concrete reaches high temperatures, water vapor transmission may not be possible through the membrane. This in turn can result in moisture being trapped in the concrete.

The results of resampling the chloride content should be studied with care. Although half of the resamples showed an increase in the chloride content, the other half indicated a decrease in chloride content. This may imply a downward movement of chlorides in the concrete. However a few chloride profiles taken from the original concrete indicated the present trend of chlorides being highly concentrated on the top and decreasing with depth. This condition rules out the idea of substantial downward movement of the chlorides in the decks. Furthermore, if the chlorides had moved downward the chance of an increase in chloride content at the depth of 1-1/2 in. (3.8 cm) to 2 in. (5.1 cm), or the general sampling depth, would have been more than the decrease in the chloride content due to a higher concentration of chlorides above that level. Therefore, it seems that the procedure used to measure chloride content was not accurate enough to find the change in chloride content which could have been much smaller than the chloride content itself. The reason for this and potential solutions to the problem are further explained below.

- Chloride content is highly sensitive to depth. Samples are taken by drilling a hole to a depth of 0.5 in. (1.3 cm) above the desired depth and removing the powdered concrete before drilling the additional 0.5 in. (1.3 cm). The drilling depth is checked periodically by inserting a scale through the hole until the satisfactory depth is reached. The procedure, however, does not guarantee the exact desired depth. A more accurate alternative is the use of a scribed depth indicator attached to the drill to insure the proper sampling depth is reached while drilling (for more information see Reference 1).

- The procedure requires that extra care is taken not to contaminate samples at the sampling depth by abraiding highly contaminated concrete from the sides of the hole above the desired depth. An alternative to overcome this problem is to reduce the hole diameter when drilling through the sampling depth.

Chloride profiles taken from patches can definitely identify the chloride proofing characteristics of the system regardless of the nature of the sampling procedure. From the results it was clear that a severe chloride leakage had occurred in only one sampling location. In the six remaining sampling locations, if 0 percent chloride content of the fresh patch material as obtained from one sample in the previous tests was considered base data, the chloride penetration would be very small and below 0.36 lb/c.y. (0.21 kg/m^3). However, it should be kept in mind that the concentration of original chlorides in aggregate and mixing water can be at the same level. Furthermore, the nature of the chloride content with depth for these samples suggested that the chlorides had not penetrated into the concrete in those locations. This agrees with the tests conducted on the Roza Canal bridge (82/106) in the previous TRAC/WSDOT bridge deck membrane research (5). That bridge was waterproofed immediately after construction with a membrane system lower in quality than system (C). After 14 years of service, tests revealed considerable chloride intrusion only in one location close to the curb out of seven locations tested. The original chloride content of that bridge was found to be about 0.3 lb/c.y. (0.18 ky/m^3). The current work, on the other hand, indicated the presence of a relatively high concentration of water in the concrete. An explanation is that the AC/membrane system had generally been able to prevent the intrusion of chlorides into the concrete, possibly by screening the chlorides while some solutions passed through the AC mix and membrane. For example, concrete and also some concrete sealers have shown that they can act as a chloride screen, allowing a larger proportion of water to pass than chloride ions (3). It may be that the thickness and density of the AC as well as the thickness of the membrane are important factors in determining the chloride screening characteristics of the system.

SUMMATION

The discussion presented earlier reveals that the following factors influence the permeability of AC/membrane systems:

1. presence of crushed aggregate next to the membrane;
2. membrane thickness;
3. AC density, and
4. AC thickness.

The author suggests the following order of importance for these factors:

1. Eliminating the presence of crushed aggregate next to the membrane is the most important factor in providing impermeability for the system. Suggested measures to achieve impermeability include use of a finely graded asphalt mix, such as WSDOT class "G" mix, in the bottom portion of AC to act as a cushion, or use of intermediate protection boards under the AC overlay as practiced in Ontario (8). The protection boards are typically 1/8" (3 mm) and are asphalt impregnated (7).
2. Quality control of membrane thickness ranks second in importance. The WSDOT membrane application provisions specify the rate of membrane application as 0.55 ± 0.10 gal./s.y. (2.5 ± 0.5 lit/m^2) but does not specify the thickness. In order to better achieve quality control, a minimum acceptable thickness such as 1/8" (3 mm) (depending on grade and superelevation) is suggested for the rubberized asphalt membrane.

3. AC density ranks third in importance. The object is to provide a more impermeable overlay with minimum amount of voids in the system, and one way to achieve this is through compaction. On bridge decks vibratory compactors are not allowed and compaction of AC is generally done by static steel drum compactors. However, pneumatic rollers may be more effective.

4. An asphalt overlay thickness of more than that used currently (i.e., 1.5" to 1.8") may not be desirable because it adds to the dead weight of the bridge.

CONDITION OF REINFORCED CONCRETE DECKS

Six years after their rehabilitation and protection, most of the concrete decks were not in a satisfactory condition. Chain dragging the AC detected the magnitude of the defective areas as 0.7 percent (90/136 S), 0.9 percent (90/140 S), 1.5 percent (90/145 N), 0.05 percent (90/145 S), and 1.7 percent (82/20 N) of the test lanes. The coring program distinguished the defects in the AC from the defects in the concrete and found the latter to be 0.7 percent (90/136 S), 0.8 percent (90/140 S), 1.5 percent (90/145 N), 0.05 percent (90/145 S), and 0.3 percent (82/20 N) of the test lanes.

Defects in the concrete were found in two forms, delaminations under sound overlays (see Figure 7), and spalling and severe disintegration of the concrete associated with pattern cracking in the AC (see Figure 8). The latter was mainly detected in the patched areas. Concrete defects were located around, in the boundary of, and within the patched areas (see Figures 9, 10, 11, and 12) and were concentrated in the wheel paths. Figures 13, 14, and 15 illustrate the approximate locations of the patched concrete and indicate deterioration in bridges 90/136 S, 90/140 S, and 90/145 N, respectively. Note that the areas of deterioration in the latter figures are not drawn to scale and are only symbols. The previous TRAC/WSDOT bridge deck membrane research had revealed concrete deterioration around and in the boundary of the patches for bridge 285/10 (Columbia River) eight years after its rehabilitation and protection (5). Those defects were also located in wheel paths.

Half-cell tests conducted in the core locations found both passive and active states of rebar corrosion (based on ASTM C876 classification) in the decks, whereas pre-rehabilitation tests generally detected active corrosion (see Appendix A). In reviewing the pre-rehabilitation half-cell readings, one should keep in mind that the ground might not have been satisfactory in those tests. The results of the current study's half-cell tests as well as the condition of the concrete in the core locations are presented in Table 9 for each bridge. As shown in the table, these results visually confirmed the location of the deterioration as described earlier. In Table 10, the half-cell readings for each bridge deck are classified as non-corroding, questionable, and corroding (ASTM C876 classification) and coincide with the magnitude of the concrete defects found by chain dragging. As shown in the table, the test lane on bridge 90/145 N (driving lane) with the highest percentage of corroding potentials also had the highest percentage of defects in its concrete, whereas the reverse was true for the test lane (passing lane) on bridge 90/145 S.

DISCUSSION

Deterioration of the concrete either originates in the original concrete or the patch concrete. The first type includes the deterioration around the patches as well as in the boundary of patched areas. The cause of this type of deterioration may be outlined as follows:

Figure 7. Concrete Delamination (Patch) Under Sound AC Overlay and Membrane.

Figure 8. Severe Disintegration of Concrete (Patch) Associated with Pattern Cracking of AC.

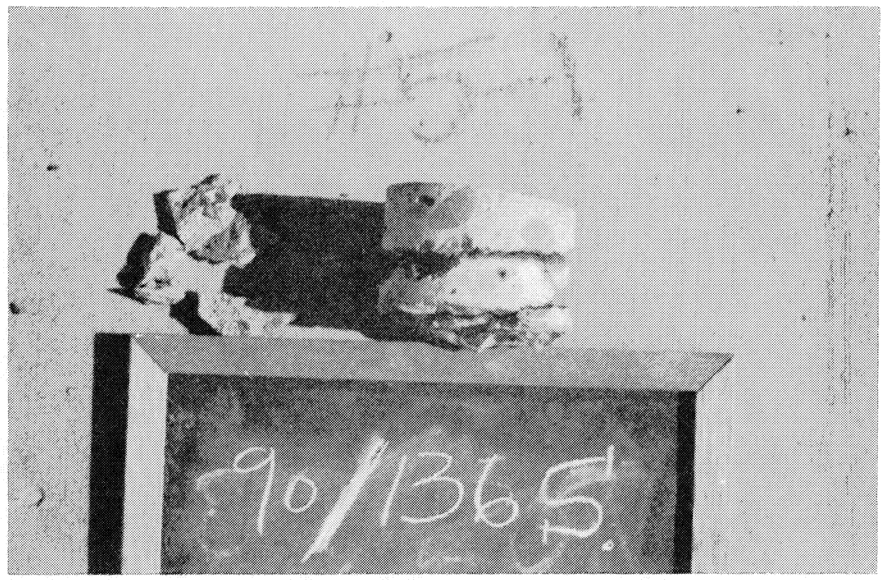


Figure 9. Concrete Delamination (Original) Around a Patched Area.

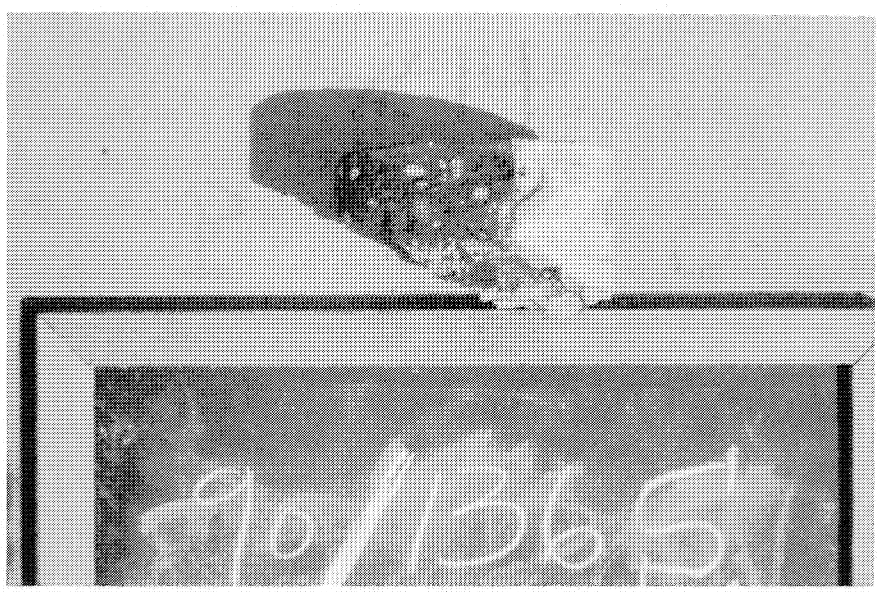


Figure 10. Concrete Delamination (Half Patch, Half Original) in the Boundary of a Patched Area.

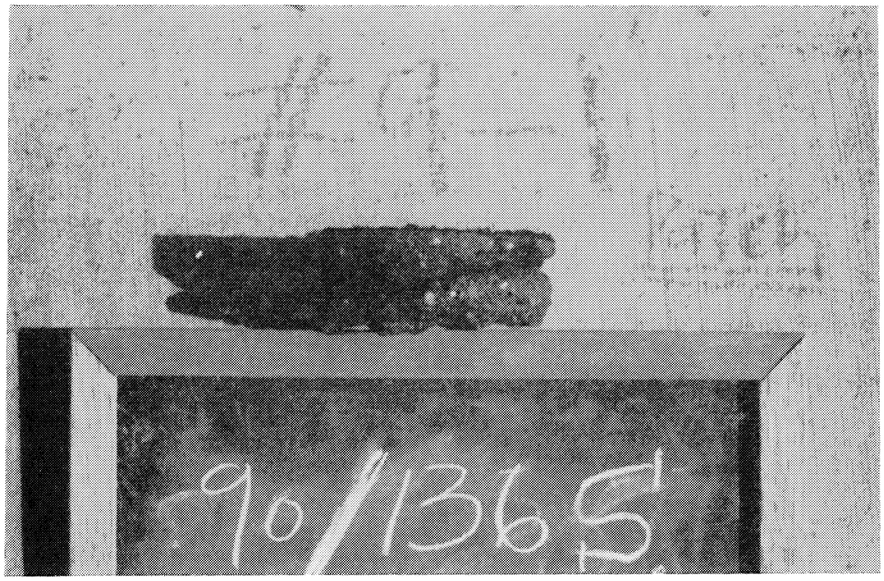


Figure 11. Delamination of Patched Concrete.

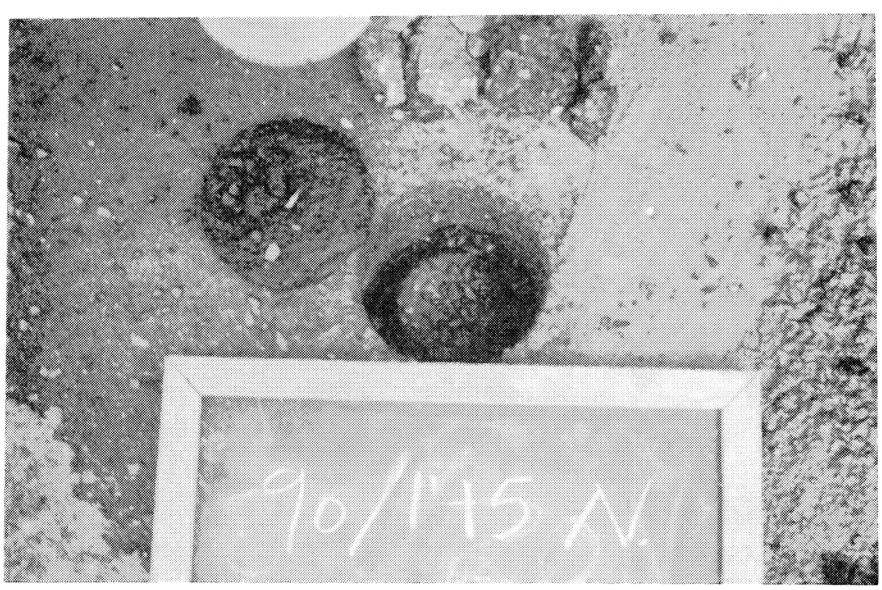


Figure 12. Severe Cracking of AC and Disintegration of Patched Concrete. Note the Conical Shaped Patched Material Left in the Core Location After Drilling Through Concrete.

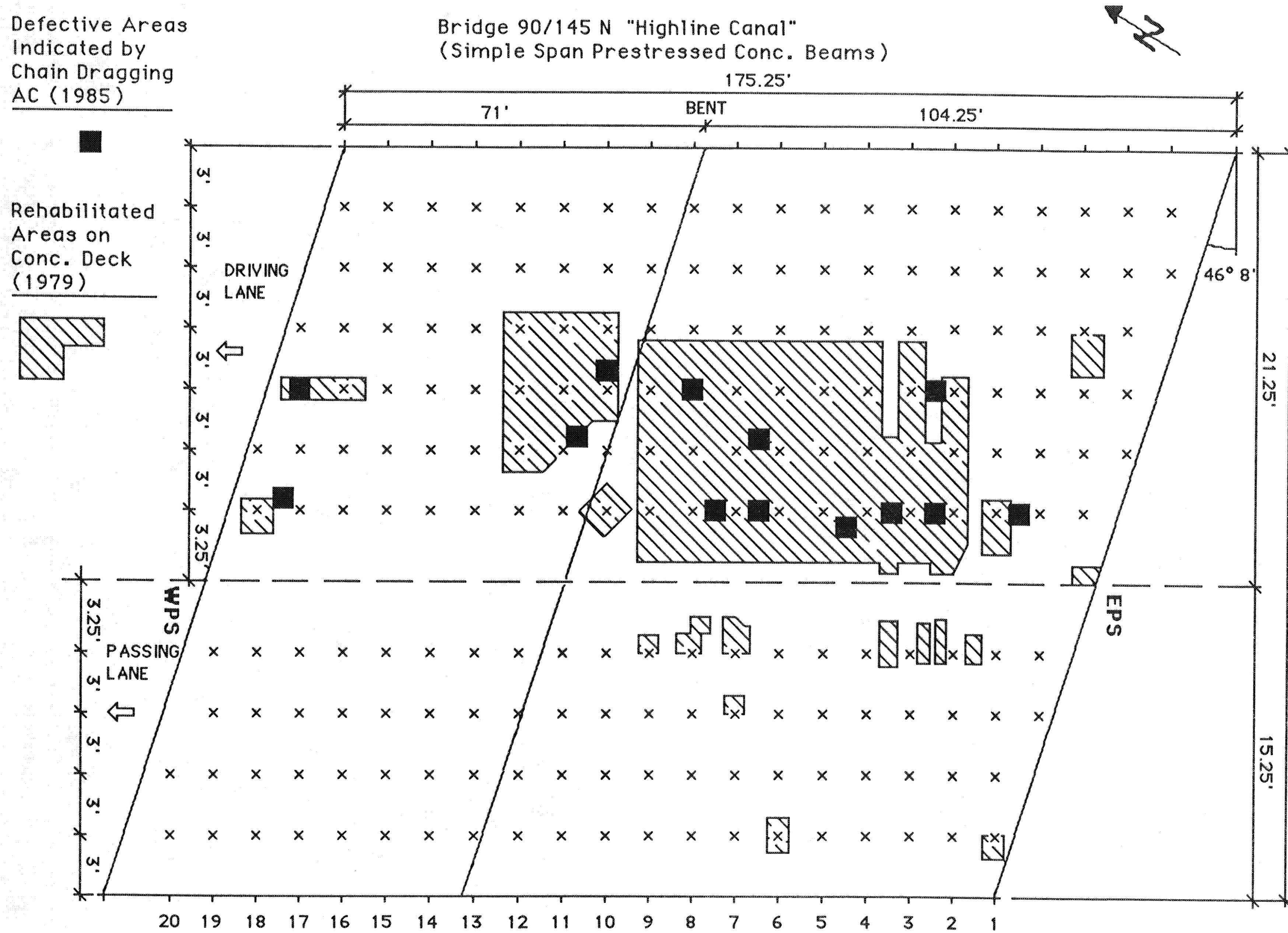


Figure 15. Superimposing Rehabilitated Areas and Defective Areas Indicated by Chain Dragging.

Bridge 90/136/S "S. Cle Elum Rd. OC"
(Continuous Concrete Box Girder)

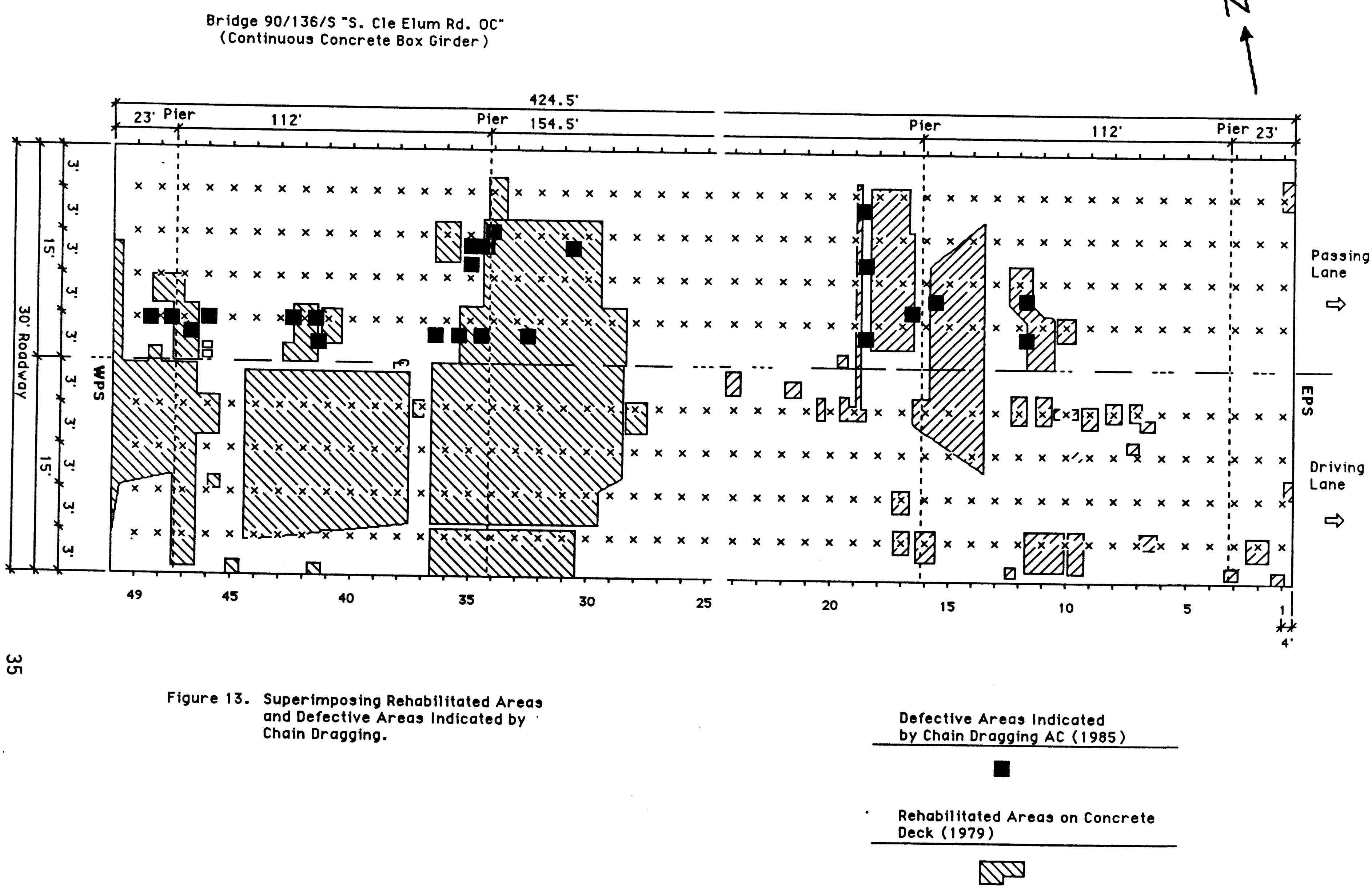


Figure 13. Superimposing Rehabilitated Areas and Defective Areas Indicated by Chain Dragging.

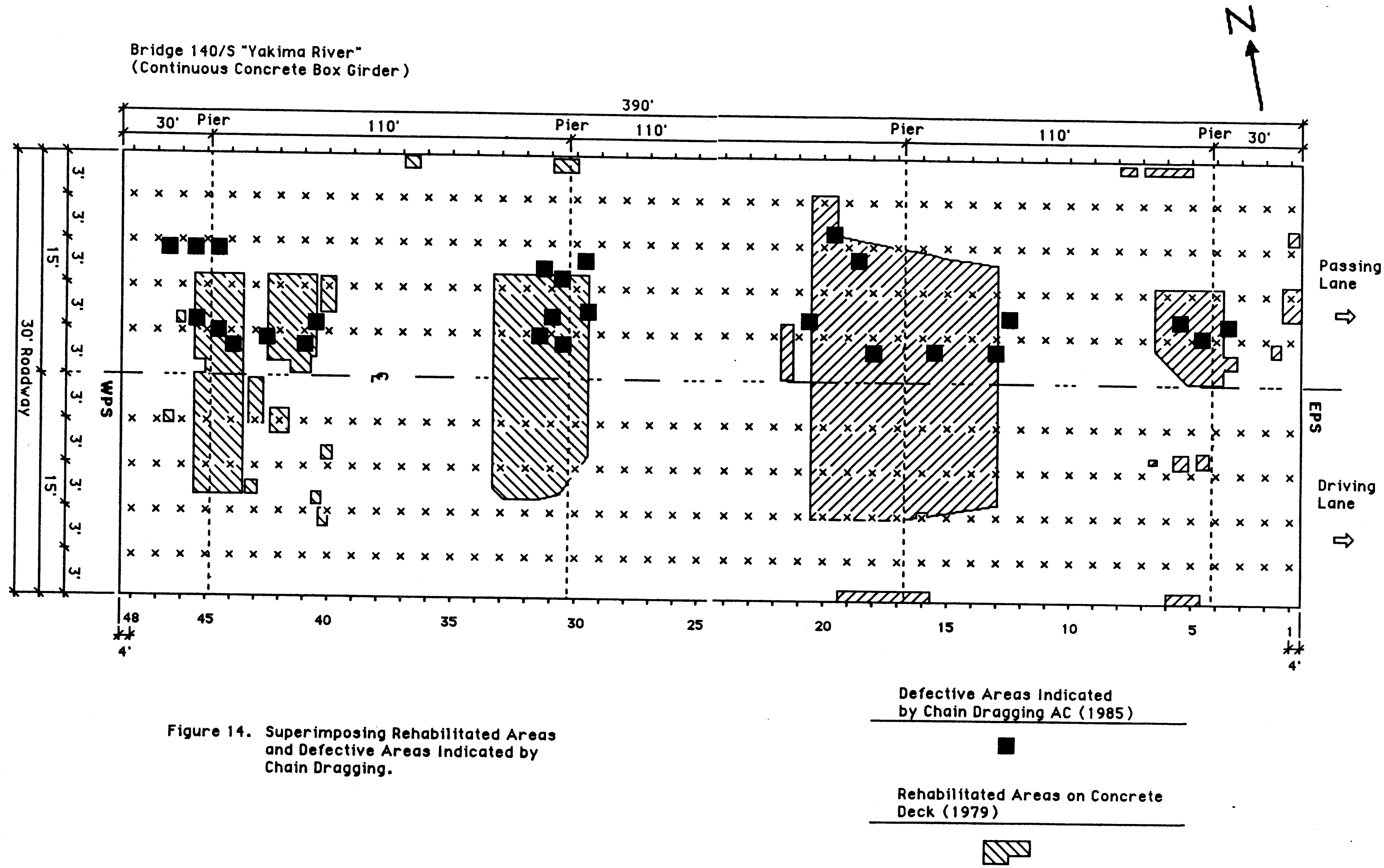


Figure 14. Superimposing Rehabilitated Areas and Defective Areas Indicated by Chain Dragging.

Table 9. Correlation of Ranked Half-Cell Readings with Delaminations for each Tested Bridge Deck

BRIDGE NO.																			
90/136 S	Half-cell[1] (Volts)	.112	.126	.141	.148	.154	.170	.190	.205	.206	.238	.248	.268	.273	.284	.320	.369	.397	.431
	Delam.[2]							D				D			D	D	D	D	D
	Nature of Concrete[3]											P						B	
90/140 S	Half-Cell (Volts)	.133	.145	.150	.152	.154	.155	.169	.177	.177	.184	.190	.217	.315	.429	.454			
	Delam.									D		D		D	D	D			
	Nature of Concrete						P				P	P			B				
90/145 N	Half-Cell (Volts)	.109	.128	.212	.244	.278	.328	.346	.353	.375	.389	.409							
	Delam.				D		D	D			D	D							
	Nature of Concrete						P				P	P							
90/145 S	Half-Cell (Volts)	.058	.083	.120	.148	.172	.187	.202	.256	.272	.305								
	Delam.										D								
	Nature of Concrete																		
82/20 N	Half-Cell (Volts)	.083	.107	.195	.200	.233	.235	.251	.267	.281	.419								
	Delam.										D								
	Nature of Concrete										B								

(1) All readings are negative
(2) "D" indicates delamination
(3) "B" indicates boundry of Patch, "P" indicated within Patch

-	Rebar corrosion	Original chloride contamination Concrete wetness Macro-cathodic effects of patch
-	Rebar level stress	Wheel path traffic impact Small rigid rebar cover

Wetness has an important effect on the electrical resistivity of concrete. A concrete saturation of about 55 percent (the average saturation found in the decks) may decrease the resistivity of dry concrete from 6×10^6 ohm-cm to about 70×10^3 ohm-cm, a condition which some consider low enough for corrosion to be active in the presence of chloride contamination (4). The macro-cathodic effects (large cathodic effects intensifying galvanic corrosion) of patches on deterioration in the original concrete will be higher, as the patches provide large chloride-free areas next to the contaminated concrete.

Table 10. Classification of Half-Cell Readings on Each Bridge and Comparison with Concrete Deterioration

Bridge No.	% of Half-Cell Readings			Detected deterioration % of deck area
	Not Corroding < 1.20 V	Questionable 1.20 - 1.35	Corroding > 1.35 V	
90/136 S	39	44	17	.7
90/140 S	73	13	14	.8
90/145 N	18	45	36	1.5
90/145 S	60	40	0	.05
82/20 N	30	60	10	.3

(1) detected by chain dragging, confirmed by coring

Repeated rebar level stress induced by traffic impact, especially in the wheel paths, can propagate incipient deterioration initiated by corrosion. The steel in the concrete may also act as a stress riser. Thicker, rigid rebar covers could possibly alleviate the intensity of the stress so that the fatigue life of the system could be prolonged. The concrete around patched areas may have as small a rebar depth as the patched areas.

The causes of deterioration originating from the patches and detected in SR-90 bridges within the patched areas may be outlined as follows:

- Rebar corrosion
  - Chloride contamination caused by chloride leakage
  - Concrete wetness
  - Nature of patch material
- Rebar level stress
  - Wheel path traffic impact
  - Small rigid rebar cover
- Inferior patched concrete

Coring deteriorated patch material in a few locations indicated that patch deterioration was caused by deterioration above the interface rather than debonding. Corrosion caused by spot leakage of chlorides into the patch material was documented in one location by both a half-cell test and the presence of rust. Corrosion deterioration in the patch material was especially prevalent in bridge 90/145 N (see Table 9 for half-cell results).

Another cause of corrosion in patch material may be the nature of its chemistry. Cement such as the fast setting cement used in these applications may not be as alkaline or have as high a pH value as portland cement. In the absence of high pH values concrete cannot act as a protective environment and rebar may corrode in the presence of moisture. A wet, cured patch generally is not dry. However, if patches are dry at the time of membrane application, moisture still may penetrate later from the environment and be trapped under the membrane.

The strength of the concrete is a determining factor for deterioration. Inferior concrete material may deteriorate faster in the presence of corrosion or it may disintegrate under traffic impact even in the absence of corrosion. In determining concrete strength the focus should be on the durability properties of the concrete in addition to its initial strength.

The following measures are believed to be effective in alleviating the problem of concrete deterioration:

- specify the strength, durability, and fatigue properties for the patch concrete so that they are comparable to those of the portland cement concrete. Test procedures and critical values need to be established to determine durability under freeze-thaw and fatigue under compression for this purpose;
- specify the pH for the patch concrete so that it is comparable to that of the PCC to prevent corrosion in the patched areas.

If pH adjustments are not made, epoxy coating rebar is a possible corrosion prevention technique. However, based on WSDOT's field experience, when rebar is epoxy coated the substrate is inevitably coated and hardened prior to placing the patch material. This can affect the bond between the substrate and the patch adversely. If the rebar is epoxy coated, epoxy coating the concrete substrate (or coating with other types of polymers) to provide a tacky bonding material just prior to application of the path is suggested.

The procedure for concrete deck repair is an additional factor which may contribute to deterioration after rehabilitation. Using jackhammers to remove concrete may cause damage to surrounding concrete. In this regard, hydrodemolishing concrete may be less harmful. The bond between the repaired and the original concrete should also be given special consideration in repair procedures.

COMMENTS ON WSDOT'S MEMBRANE SELECTION CRITERIA

The following section concerns the five elements of WSDOT membrane selection criteria: extent of deterioration, concrete cover thickness, average daily traffic, chloride contamination, and surface compatibility. More information on the WSDOT membrane criteria is presented in Chapter I (page 10) under "Classification of Candidate Sites Relative to Present WSDOT Membrane Selection Criteria."

EXTENT OF DETERIORATION

The WSDOT criteria permit membrane application when less than 5 percent of the deck area has deteriorated. The extent of deterioration generally influences the feasibility and economy of the rehabilitation. Usually it is not practical and economical to patch larger areas using fast setting concrete mixes. In this case application of a concrete overlay which fills the removal areas at the time of overlay is a better choice. Other items of concern are the potential for incompatibility between fast setting mixes and the original concrete, which may result in debonding shortly after application; their durability regardless of their initial strength; the nature of the protection they provide to the rebar against corrosion; and quality control's sensitivity to accelerated construction. A comparison of Table 2 with Table 10 indicates that the two test lanes that satisfied the deterioration criteria (passing lane on bridge 90/145 S and driving lane on bridge 82/20 N) at the time of rehabilitation show the lowest degree of deterioration.

It is important to note that the extent of the deterioration should apply to the rehabilitated concrete. Normally, decisions regarding the type of protection are made at least one year prior to the rehabilitation. In this case, the detected deterioration should be increased using a proper multiplier. The multiplier depends on the age of the deterioration and environmental conditions. In situations where the deterioration is highly concentrated in one lane, the extent of the deterioration of that lane may dictate the type of protection for the bridge deck.

CONCRETE COVER THICKNESS

The criteria's breakline for concrete cover thickness is 90 percent of the deck area with a cover thickness larger than 1 in. (2.54 cm). In case of membrane breakdown, the concrete cover will be the only protective measure against moisture and salt penetration. The cover also has a structural value against deterioration. Local stresses in the concrete mass caused by wheel load contact are probably concentrated at internal cracks and are smaller at deeper locations. If the rebar has corroded prior to protection, causing incipient cracking around the rebar only, then the contribution to deterioration from a concentration of wheel load stresses at the cracks would probably be smaller in the presence of a larger cover thickness. Asphalt concrete, because of its inferior structural properties, may not be able to distribute stresses in the mass as rigid cement concrete can.

The pachometer survey results conducted during the present study lack the accuracy to judge the effects of the cover thickness of the test bridges (see "Comments on the Field Evaluation Techniques" in Chapter II). In view of the above discussion and the results of the previous TRAC/WSDOT membrane research (5), which correlated the deterioration with cover thickness, it would be prudent to require thicker concrete covers for AC/membrane applications. For instance, 90 percent of a deck area with a cover thickness larger than 1 in. (2.54 cm) and 50 percent of a deck area with a cover thickness not less than 1.5 in. (3.81 cm) seems appropriate.

AVERAGE DAILY TRAFFIC (ADT)

Under heavy traffic, asphalt concrete overlays normally are not as durable as concrete overlays. Thus, they sometimes deteriorate rapidly in the presence of large traffic volumes. The ADT criterion's breakline is 10,000 ADT and 7.5 traffic index in order to provide about 10 to 15 years of service. All of the test sites satisfied ADT requirements. The general conclusion is that the damage to the overlays due only to traffic wear is negligible at this time. However, as included in the criteria, the ADT provision does not apply to interstate routes. In this case, because of the importance of the transportation link, a rigid overlay (latex modified concrete) is applied regardless of the ADT.

The ADT criteria also consider the effects of heavy traffic volumes on flexible membrane systems placed on rigid concrete decks. WSDOT is concerned that lateral forces on curved structures and bouncing or skipping behind rough transitions, such as expansion joints on high volume routes and on routes with high truck usage, cause repeated flexing of the AC and the membrane, which in turn causes premature failure of the membrane.

CHLORIDE CONTAMINATION

Rebar level chloride contamination exceeding 2 lb/c.y. (1.18 kg/mP^3) for 40 percent of the samples tested is the chloride contamination criterion's breakline. Studies indicate that the areas with cl >2 lb/c.y. (1.18 kg/m^3) have a greater potential for corrosion deterioration in the presence of moisture. Membranes may also act as a vapor barrier, thus collecting moisture in the concrete. Here again, a comparison of Table 2 with Table 10 indicates that the magnitude of present corrosion is related to the extent of original chloride contamination. As an example, the only test lane with no active potentials (passing lane of bridge 90/145 S) at the present is the one with 0 percent original contamination as designated in the criteria.

SURFACE COMPATIBILITY

Surface compatibility is a problem when aged asphalt concrete overlays have to be removed prior to applying new lifts of an AC/membrane system. However, since the decks were bare and the deteriorated areas were thoroughly patched and leveled, this item of the criteria does not apply.

COMMENTS ON THE FIELD EVALUATION TECHNIQUES

CHAIN DRAGGING

The results indicate that chain dragging AC can reveal deterioration in the concrete. However, the results of the previous TRAC/WSDOT bridge deck membrane research (5) and also results of research conducted by the Ontario Ministry of Transportation (6) have shown that the procedure is capable of identifying only a fraction of the concrete deterioration, depending on the progression of the deterioration. The author recommends the chain dragging procedure when surveying asphalt covered decks until more effective techniques such as radar and thermography are practiced. The author also recommends that rehabilitation projects map repair areas on bridge decks. Superimposing such data over those obtained from chain dragging AC will lead to a better understanding of problems detected. In places in which there are doubts over the origin of the problems, dry coring AC at a few locations and sounding concrete can distinguish the deterioration in the concrete from that in the AC.

HALF-CELL

An excellent correlation between high half-cell potentials and concrete deterioration was obtained. The correlation is presented in Table 11 with the overall half-cell readings classified into three ranges and ranked within each range. As is recognized by ASTM, the first range (potential less negative than -0.20 v) corresponds to a 10 percent probability of corrosion. The second range (-0.10 v > potential > -0.35 v) corresponds to a 50 percent probability of corrosion and the third one (potential more negative than -0.35 v) corresponds to a 90 percent probability of corrosion. As shown in Table 11, the results of this work indicate 11 percent, 36 percent, and 80 percent occurrence of deterioration for the three ranges described, respectively.

PACHOMETER SURVEY ON AC

The results indicate that by using the pachometer the depth of the rebar from the AC surface can be determined up to 2 in. (5.08 cm) smaller than the actual depth. Thus, a correction factor needs to be obtained by measuring the actual depth (as explained in Appendix B, "Details of Experiment Design"). However, different correction factors in one bridge can be obtained, depending on where the rebar is exposed. This can lead to a maximum of 0.7 in. (1.78 cm) error in determining the concrete cover thickness. This error is probably caused by the characteristics of magnetic aggregate in the AC. The error is also caused by the greater rebar depths when measured from the AC surface, normally greater than 3 in. (7.62 cm). The latter affects the accuracy of the instrument, which in normal conditions (0 to 3 in. or 7.62 cm thickness) is +/- 1/8 in. (0.3 cm) (57). Therefore, the pachometer should be used with

Table 11. Overall Correlation of Ranked Half-Cell Readings with Delaminations

		Ranked Half-cell Readings[1] (Volts)																												Delams. % of Readings
Range[2] (Volts)	< |0.20|	.058	.083	.083	.107	.109	.112	.120	.126	.128	.133	.141	.145	.148	.148	.152	.154	.154	.155	.169	.170	.172	.177	.177	.184	.187	.190	.190	.195	11%
Delam.[3]																								D			D	D		
Range (Volts)	|.20| - |.35|	.200	.202	.205	.206	.212	.217	.233	.235	.238	.244	.248	.251	.256	.267	.268	.272	.273	.278	.281	.284	.305	.314	.320	.328	.346				36%
Delam.											D	D						D			D	D	D	D	D	D				
Range (Volts)	> |0.35|	.353	.369	.375	.389	.397	.409	.419	.429	.431	.454																			80%
Delam.			D		D	D	D	D	D	D	D																			

1 All readings are negative
2 Negative sign is eliminated
3 "D" indicates delamination

caution on asphalt covered decks to determine the depth of rebar and at least two actual measurements of the rebar depth should be made to determine a correction factor. If the correction factors obtained from these two measurements do not agree, then the pachometer survey will be of little value on that deck.

REFERENCES

1. Clear, K.C., "Evaluation of Portland Cement Concrete for Permanent Bridge Deck Repair", Federal Highway Administration, Report No. FHWA-RD-74-5.

2. Jenkins, G. H., and Butler, J. M., "Internally Sealed Concrete", Federal Highway Administration, Report No. FHWA-RD- 75-20.

3. Pfeifer, D.W., and Scali, M.J., "Concrete Sealers for Protection of Bridge Structures", NCHRP 244, 1981.

4. "Corrosion of Metals in Concrete", ACI Journal/January-February, 1985.

5. Babaei, K., and Terrel, R.L., "Performance Evaluation of Waterproofing membrane Protective Systems for Concrete Bridge Decks", A Report Prepared for Washington State Department of Transportation, 1983.

6. Manning, D.G., and Hold, F.B., "Detecting Deterioration in Asphalt-covered Bridge Decks", a paper for presentation at the Annual meeting of the Transportation Research Board, Research Development Branch, Ontario Ministry of Transportation and Communication, 1983.

7. "Durability of concrete Bridge Decks", NCHRP 57, 1979.

8. Manning, D.G., and D.H. Bye, "Rehabilitation Manual, Part II: Contract Preparation," Research and Development Branch, Ontario Ministry of Transportation and Communication, 1984.

9. Clear, K., "Permanent Bridge Deck Repair," Public Roads, Volume 39, No. 2, September 1975.

APPENDIX A

BACKGROUND INFORMATION ON CANDIDATE TEST BRIDGES

WSDOT

END-OF-PROJECT REPORT

FOR

CONTRACT #1594

(BRIDGES 90/136 S, 90/140 S, 90/141 S, 90/145 S AND N)

DEPARTMENT OF TRANSPORTATION
INTRA-DEPARTMENTAL COMMUNICATION

DATE: December 5, 1979

FROM: R.C. Schuster/T.E. Lyon TEL

Phone:

SUBJECT: Contract 1594, SR-90, Highline Canal to Gold Creek, Bridge Deck Repair, I-90-2(130)51

To: W.A. Bulley/T.G. Gray

THRU: R.C. Schuster/K.E. Wheeler

END OF PROJECT REPORT (CONT.)

A previous installment on the End-of-Project Report was made dealing exclusively with the special concrete overlay. The following are comments concerning the remainder of the project.

This project consisted of repairs and overlays to eight bridge structures on SR-90. Three bridges received the special concrete overlay and five received the conventional deck repair, membrane and asphalt concrete overlay. No particular surprises resulted as the work was executed, but a number of comments are offered for what they may be worth to others.

The project work was originally conceived to be accomplished in the 1980 construction season. Data for the Design Report was gathered and prepared late in 1978. The cost estimate was developed, by using the deck condition survey from the District Lab. assuming a removal depth of 2½ inches to get a volume, and multiplying by two. Before the 1978/79 winter was ended, it became evident that deterioriation of many of the decks was rapidly accellerating. The project was advanced into the 1979 season and was ultimately completed in that season. The volume of bridge deck repairs overran the plan quantity by 25%; that is 2.5 times the original bridge condition figure and we did the work a year ahead of the original schedule! I don't mean this as a criticism of anybody's methods of information gathering or estimating ability. It is however, an indication of the rate of deterioration combined with the tendency for the repair areas to "grow" when work is performed. The conclusions I draw are that we need more accurate bridge condition survey techniques, to make generous allowance for the on-going deteroriation, and to have uniform direction as to what degree of rusty re-bar and "punky" concrete removal really is necessary. The pay volume for the repairs on five bridge decks was 1694 cu.ft. The area repaired was about 5151 sq.ft. The average depth calculates to 4 inches.

For the five bridge decks that were repaired with pre-packaged quick setting grouts, the Contractor used Jet Set Super X. This material was well suited for the sometimes large repair areas on these structures. Jet Set Super X has a retarded initial set period of 15 min. to 30 min. that permits a succeeding batch to be placed prior to the initial setting of the preceeding batch. Thereby, partial cold joints are mostly eliminated, more consolidation of the grout into the patch area can be done and better surface finishing can be accomplished. Some other prepackaged grouts have about a five minute initial set time, or even less in hot weather. The Contractor took more care to compact the grout and finish the edges than anybody I have seen. Even so, a significant number of failures occurred where the grout patch lost bond with the original concrete within a few days after placing. We feel that all the right things were done to prepare the area to be patched, by sawing the perimeter of the area, making the sides vertical and scrupulous cleaning before patching. Why some patches lose edge bond and others stay tight, I can't explain. Maybe local vibration in the structure due to passing traffic is part of the reason for loss of bond. The cost in time and money to repair these areas is significant. The Contractor anticipates a certain failure rate in his bid. Techniques or materials which significantly reduce the failure rate of patches will surely reduce costs.

We were not initially impressed with the type of expansion joint seal specified for use on Brs. 90/141S and 90/145 N&S. The seal used was an Acme Strip Seal. This seal consists of a downward folding rubber strip held between steel bars. We did not specify that the seal extend up the curb. The butt joint between the seal and the existing rubber filler will always be poor. Some winter problems were predicted by Maintenance personnel who observed the installation. Their apprehensions will be tested through the coming winter. Due to the heavy use of sand on this roadway, it was felt that sand will be held into the down-folded rubber seal strip by ice and as the bridge works, the sand will grind on the rubber. The second point concerns the skews of these three structures, of 46° to 53° right, which approximates the angles of a snowplow blade. It was feared that the blade could catch in the joint opening where the seal folds downward. I had occasion to look at the Transflex joint seal installed about three years ago when BR 90/141N was repaired and overlaid on CT-0294. This seal appears to be doing an excellent job. It does not leave an opening over the expansion joint and has the bulk and stiffness to make a butt seal at the curb line. We specified the Transflex seal with the PS&E but a change to the Strip Seal type was made by Headquarters with an explanation that the FHWA did not approve the Transflex type. To my observations, the Transflex joint seal is a superior installation to the flexible strip we just installed.

As a comparison of some testing techniques to actual removal of unsound concrete we have diagrams of some of the bridge decks. The results of half-cell electrical potential, chloride test and actual removal are all superimposed. I have cross-hatched the areas actually removed in red. The areas above 0.35 volt electrical potential (active corrosion?) are colored green. Values of chloride tests are shown but no contours of intensity are shown. A chloride test of 2.0 lb/ft^3 is considered by some to be the threshold of active corrosion. The point I am making with these drawings is that no correlation, between the two types of tests and actual concrete removal appears evident. The one thing that can be seen is that the potential for further deck deterioration, in areas where concrete was not replaced but has high chloride content, is large. I can't see that we can keep the concrete sufficiently dry to stop corrosion. During winter, atmospheric moisture can enter the underside of the deck.

Can't sufficient moisture collect from condensation on the underside of the membrane, until the moisutre evaporates from the concrete sometime in the spring, to resume the corrosion process? On the reinforced approach slabs, there is a constant source of moisture from the underlying soil to be trapped against the membrane.

TEL:tg
cc: K.Wheeler

WSDOT

DESCRIPTION OF MATERIALS USED

FOR

CONTRACTS #1594 AND 1481

(BRIDGES 90/136 S, 90/140 S, 90/141 S,
90/145 S AND N, AND 82/20 N)

DT FORM 350-071
REVISED 10/77

07045

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION
REQUEST FOR APPROVAL OF MATERIAL SOURCES

MATERIAL LABORATORY

Date June 27, 1979

Cont. No. 1594 F. A. No. I-90-2(130)S1 City/County or S. R. No. 90

Section Gold Creek to Highline Canal

Bid Item No.	DESCRIPTION OF MATERIAL	SOURCES OF SUPPLY: Local Supplier	SOURCES OF SUPPLY: Manufacturer's Brand or Pit No.	Approval Action *
4	Bridge Deck Repair			
	Grout	Dicon Supply	Jet Set Super X	✓
		CR Watts	Set 45	✓
	Curing Compound	United Constr. Supply	Horn Clear Seal 150	2
5	Epoxy Resin	Macon Supply	Probound ET 150g	✓
		Protex Industries		
		Dicon Supply		
6	Membrane Waterproofing			
	Asphalt Binder	Chevron USA, Inc.	AR 4000W	✓
		Husky Oil.		✓
		U.S. Oil & Refinery		
	Rubber	Arizona Refining Co.	G-274	✓
	Polypropylene Fabric	Phillips Fibers Corp.	Petromat	✓
	Extender Oil	Arizona Refining Co.	Califlux	✓
7	Waterproof Expansion Device			
	Seal	ACME	ACME Strip Seal AS400	✓
	Anchor Bolts	Cascade Contractors Supply Inc.	Molly Parabolts	✓
		Northwest Bolt	Diamond	✓
		United Constr. Supply	Phillips Red-Heads	✓

Contractor: Sealant Systems Company

Submitted by: Mark Rohde

DEPARTMENT OF TRANSPORTATION MATERIALS LABORATORY USE ONLY

I, Thomas E. Lyon (Project Engineer), have reviewed the above items and ( ) concur, ( ) do not concur (attach comments)

Sources of supply for all items checked (✓) in approval column are approved for use on the above improvement provided the materials delivered comply with all specifications. Action on items indicated by number in the approval column is identified per the following code:
1. Source Approved. Approval for Change of Source must be secured from the Office for Construction and Materials per Sec. 3-1.7 of the Construction Manual.
2. Approval withheld; submit samples for preliminary evaluation.
3. Approval withheld; submit brand name, name of manufacturer, or treating plant.
4. Approval withheld; submit Transportation Department pit number (if known) and legal description.
5. Approval withheld; please submit catalog cuts and/or shop drawings.
6. Approval withheld;

Department of Highways — JUL 2? 1979 — PROJ. ENGR. / ASST. / OFFICE / SURVEY / LOC.

Mats File X Dist Engr 5
Val File X Matls Engr 5
Proj Engr T. Lyon (3)
State Insp Office X

Reviewed by JB Phone No. 8-234-2183

Project Engineer will submit control samples of materials as covered in Construction Manual, Chapter 9.

R. V. LeClerc
Materials Engineer

Date July 3, 79 By Jack W. Baldwin

SEE REVERSE FOR INSTRUCTIONS

DOT FORM 350-071
REVISED 10/77

07019

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIAL LABORATORY

REQUEST FOR APPROVAL OF MATERIAL SOURCES

Date April 20, 1979

Cont. No. 1481 F. A. No. 1-90-3(41)117 & 1-82-1(49)10 City/County or S. R. No. 90 & 82

Section SR 90 & 82 BRIDGE DECK REPAIRS

Bid Item No.	Description of Material	Sources of Supply: Local Supplier	Sources of Supply: Manufacturer's Brand or Pit No.	Approval Action *
& 5	Aggregates to be combined with Set 45 Chemical Action Concrete	Yakima Sand & Gravel	PS-E-141	✓
7	Membrane Waterproofing Fabric	Phillips Fibre	Petro Mat	✓
7	Rubber Additive for Membrane Waterproofing	Crafco N. W.	Atlas	✓

Department of Highways
Rec'd. APR 23 1979
OFFICE ASST.
LOC. ENGR.

Contractor:
YAKIMA CEMENT & ASPHALT PAVING CO

Submitted by:

DEPARTMENT OF TRANSPORTATION MATERIALS LABORATORY USE ONLY

I, ______ (Project Engineer), have reviewed the above items and (X) concur, ( ) do not concur (attach comments)

Sources of supply for all items checked (✓) in approval column are approved for use on the above improvement provided the materials delivered comply with all specifications. Action on items indicated by number in the approval column is identified per the following code:
Source Approved. Approval for Change of Source must be secured from the Office for Construction and Materials per Sec. 3-1.7 of the Construction Manual.
Approval withheld; submit samples for preliminary evaluation.
Approval withheld; submit brand name, name of manufacturer, or treating plant.
Approval withheld; submit Transportation Department pit number (if known) and legal description
Approval withheld; please submit catalog cuts and/or shop drawings.
Approval withheld:

Matls File X Dist Engr 5
Dist File X Matls Engr 5
Proj Engr Lyon (3)
Seattle Insp Office X

Reviewed by
Phone No. 8-234-2183

Project Engineer will submit control samples of material as covered in Construction Manual, Chapter 9.

R. V. LeClerc
Materials Engineer

Date May 8, 1979 By

SEE REVERSE FOR INSTRUCTIONS

DT FORM 350 071
REVISED 10/77

10921

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION
REQUEST FOR APPROVAL OF MATERIAL SOURCES

7741

MATERIAL LABORATORY

Date April 16, 1979

ont. No. 1481 F. A. No. 1-90-3(41)117 & 1-82-1(49)10 City/County or S. R. No. 90 & 82 1481

ction SR 90 & 82 Bridge Deck Repair

Bid Item No.	Description of Material	Sources of Supply: Local Supplier	Sources of Supply: Manufacturer's Brand or Pit No.	Approval Action *
& 10	Paving Asphalt AR-4000 W and Asphalt for tack coat	Chevron or U. S. Oil	Same Same	✓ ✓
10	Asphalt Concrete Class B aggregates	Yakima Sand & Gravel	PS-E-141	✓
& 5	Chemical Action Concrete Chemical Action Concrete	Charles R. Watts Costles Concrete Coatings	Set 45 Special Jet Set Super	✓ ✓ x 7
	Epoxy Resin	Charles R. Watts	Sikastix 370	✓

Department of Highways
Rec'd. APR 17 1979
PROJ. ENGR.
ASST. P...
OFFICE ...
ENGR...
FIELD ...
SURVEY ...
OFFICE ASST.
LOC. ENGR.

Contractor:
YAKIMA CEMENT & ASPHALT PAVING CO

Submitted by:

DEPARTMENT OF TRANSPORTATION MATERIALS LABORATORY USE ONLY

I, Bernard D. Lyon, Project Engineer, have reviewed the above items and (X) concur, ( ) do not concur (attach comments)

urces of supply for all items checked (✓) in approval column are approved for use on the above improvement provided the materials delivered comply with al ecifications. Action on items indicated by number in the approval column is identified per the following code:
Source Approved. Approval for Change of Source must be secured from the Office for Construction and Materials per Sec. 3-1.7 of the Construction Manual.
Approval withheld; submit samples for preliminary evaluation.
Approval withheld; submit brand name, name of manufacturer, or treating plant.
Approval withheld; submit Transportation Department pit number (if known) and legal description.
Approval withheld; please submit catalog cuts and/or shop drawings.
Approval withheld.

Please submit a control sample before using on project.

ts File X Dist Engr 5
d File X Matls Engr 5
Engr Lyon (3)
itle Insp Office X

Reviewed by JB
Phone No. 8-234-2183

Project Engineer will submit control samples of materials as covered in Construction Manual, Chapter 9.

R. V. LeClerc
Materials Engineer

Date April 20, 79 By Jack D. Baldwin

SEE REVERSE FOR INSTRUCTIONS

WSDOT

LABORATORY TESTS ON PATCH CONCRETE

USED FOR

CONTRACTS #1594 AND 1481

(BRIDGES 90/136 S, 90/140 S, 90/141 S,
90/145 S AND N, AND 82/20 N)

Nº 263505
MATERIALS LABORATORY
1655 So. 2nd Avenue
Tumwater, Washington 98504

WASHINGTON STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

Lab. No. M3244
Pit No.
Organization Code 454301
Contract No. 1554

C.S. No. S.R. No./Co. Rd. 90 Place ELLENSBURG Date 7-25-79 F.A. No. I-90-3(136)51 Contractor SEALANT SYSTEMS
Section COLD CREEK TO HIGHLINE CANAL - BRIDGE DECK REPAIR Sub. Contr.
Forwarded by: C.N.C.
Brand JET SET SUPER X I.D. No. Control Sample No. 1 of MODIFIED JET SET SUPER X
Sampled by T. Lyon Quantity Represented ITEM 4 - BRIDGE DECK REPAIR
, Stkpl. No. Date Sampled 7-25-79 Sampled at JOB SITE
Stockpiled for: immediate ; future ; Used at: Sta. to Sta.
Field: (Acceptance) (Rejection) based on ; use in Pit No. Date Tested
Material held pending laboratory report Aggregates: washed , scalped ; neither

ASPHALT ROAD MATERIALS (Fill out all columns) Mix Design Desired

CERTIFICATE NO	TRUCK/CAR NO.	DATE RECEIVED	PLACE RECEIVED	WHERE USED / STA. — STA.

ASPH. MIX CL. ; base ; leveling ; wearing ; course. Asph. in mix: plan %; ext. %.
Field Test Results Report all screens used:

Screens									
% Pass									
Spec's.									

MISCELLANEOUS		
Fracture: Fine	% Coarse	%
Sand. Equiv.		
Other Sieving:	wet ☐	dry ☐

Remarks: USED ON CONCRETE PATCHING

HWY FORM 350-056 (H.F. 26.61) REVISED 10/74
White Copy with Sample
Yellow Copy for Proj. Files

Project Engineer T. E. Lyon / [illegible]
Phone No. SCAN 453 [illegible]

TEST OF Jet Set Super X Lab. No.

Tested [illegible]-79 - H_2O for Test = 10.6%

Compressive Strengths:

6 Hrs	24 Hrs
4325	4950
4500	5175
4450	4975
Average - 4,4[illegible] PSI	[illegible] PSI

CL [illegible] 0%

Distribution of Report
Mat'l Files ✓
Gen'l Files X
Dist. Engr. 5
Proj. Engr. Lyon [illegible]
F.H.W.A. [illegible]
HWY Form 350-024 (H.F. 26.41) Revised 5-72

MATERIAL:

R. V. LeCLERC, P.E.
Materials Engineer

Date 9/21/79 By [signature]

N? 215708
MATERIALS LABORATORY
1655 So. 2nd Avenue
Tumwater, Washington 98504

WASHINGTON STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

Lab. No. M3258
Pit No.
Organization Code 4543CL
Place Ellensburg Date 4-25-79
C.S. No. S.R. No./Co. Rd. 90 & 82 F.A. No. Contract No. 1461 94H
Section SR 90 & 82 BRIDGE DECK REPAIR Contractor YAKIMA ASPHALT
Sub. Contr.
Forwarded by: ONC Control Sample No. 1 of *CHEMICAL ACTION CONCRETE
Brand SCT 45 I.D. No. Quantity Represented
Sampled by T. LYON Date Sampled 4-24-79 Sampled at JOB SITE
, Stkpl. No. ; Used at: Sta. to Sta.
Stockpiled for: immediate ; future ; use in Pit No. Date Tested
Field: (Acceptance) (Rejection) based on
Material held pending laboratory report Aggregates: washed ; scalped ; neither

ASPHALT ROAD MATERIALS (Fill out all columns) Mix Design Desired

CERTIFICATE NO.	TRUCK/CAR NO.	DATE RECEIVED	PLACE RECEIVED	WHERE USED / STA. — STA.

ASPH. MIX CL. ; base ; leveling ; wearing ; course. Asph. in mix: plan %; ext. %.
Field Test Results Report all screens used:

Screens									
% Pass									
Spec's.									

MISCELLANEOUS	
Fracture: Fine	% Coarse %
Sand. Equiv.	
Other: Sieving:	wet ☐ dry ☐

Remarks: 1 BAG OF AGGREGATE INCL, AS PER APPROVAL OF MAT'L #10921

HWY FORM 350-056 (H.F. 26.81) REVISED 10/74
White Copy with Sample
Yellow Copy for Proj. Files

Project Engineer T.E. Lyon / S. Olson
Phone No.

APR 30 1979

TEST OF Lab. No. M3258

6 hr. Comp. Str. = 10,225 psi
24 hr Comp. Str. = 10,363 psi

(2 hrs)

Distribution of Report
Mat'l Files X
Gen'l Files X
Dist. Engr. 5
Proj. Engr. Lyon (2)
F.H.W.A. Wiltz
HWY Form 350-034 (H.F. 26.41) Revised 5-73

MATERIAL:

R. V. LeCLERC, P. E.
Materials Engineer

Date 5-9-79 By [signature]

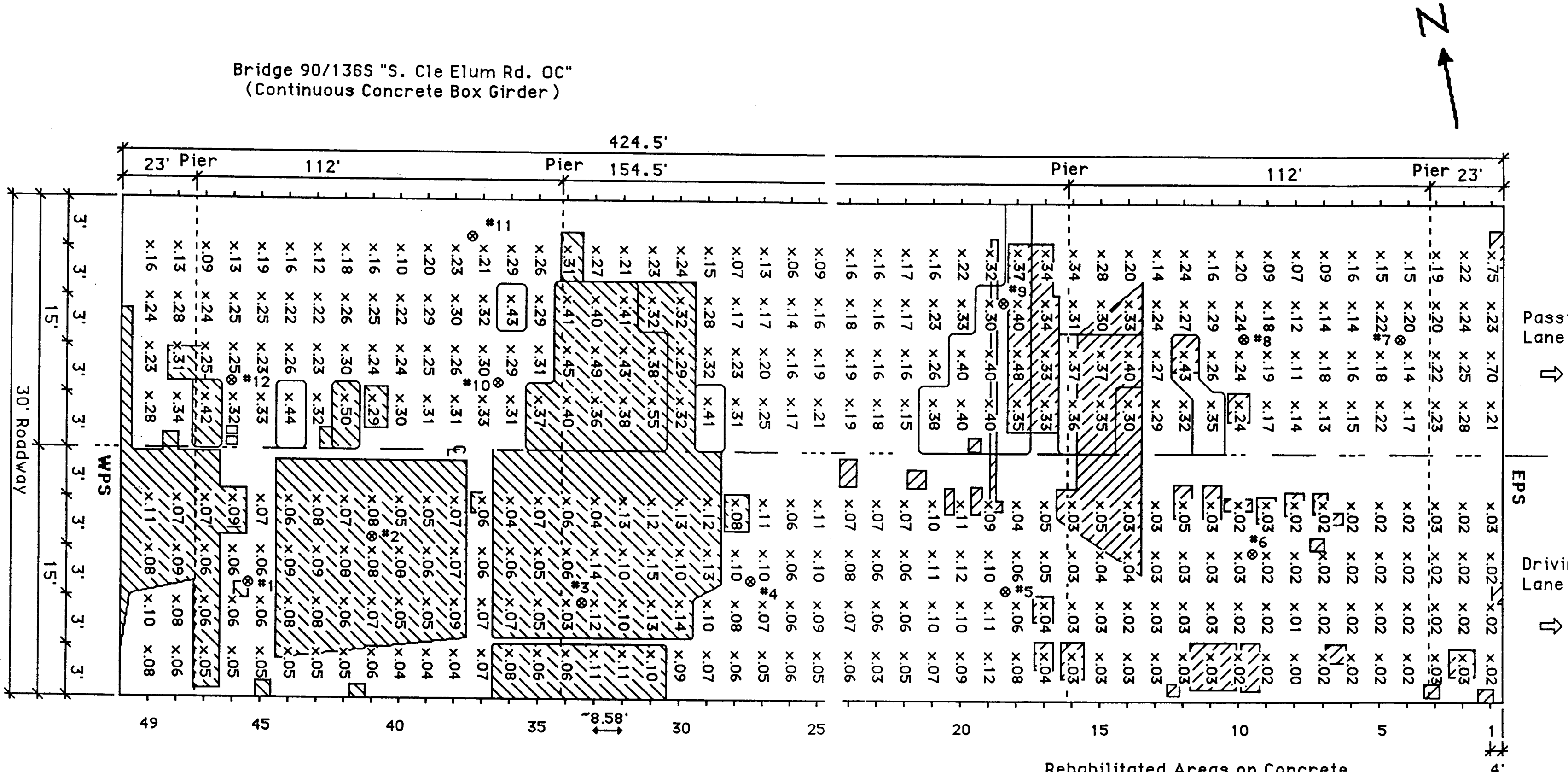
LOCATION OF REHABILITATED CONCRETE

AND RESULTS OF PRE-REHABILITATION HALF-CELL AND CHLORIDE

TESTS ON CANDIDATE TEST BRIDGES

(BRIDGES 90/136 S, 90/140 S, 90/141 S,
90/145 S AND N, AND 82/20 N)

Bridge 90/136S "S. Cle Elum Rd. OC"
(Continuous Concrete Box Girder)



Pre-Rehabilitation Data (Summer, 79)

× Half-cell Readings (volts)

⊗ Chloride Test Location

Active Half-Cell Potential Contour

Rehabilitated Areas on Concrete Deck (1979)

Pre-Rehabilitation Chloride/Half-Cell Data and Location of Concrete Repairs on Bridge 90/136 S.

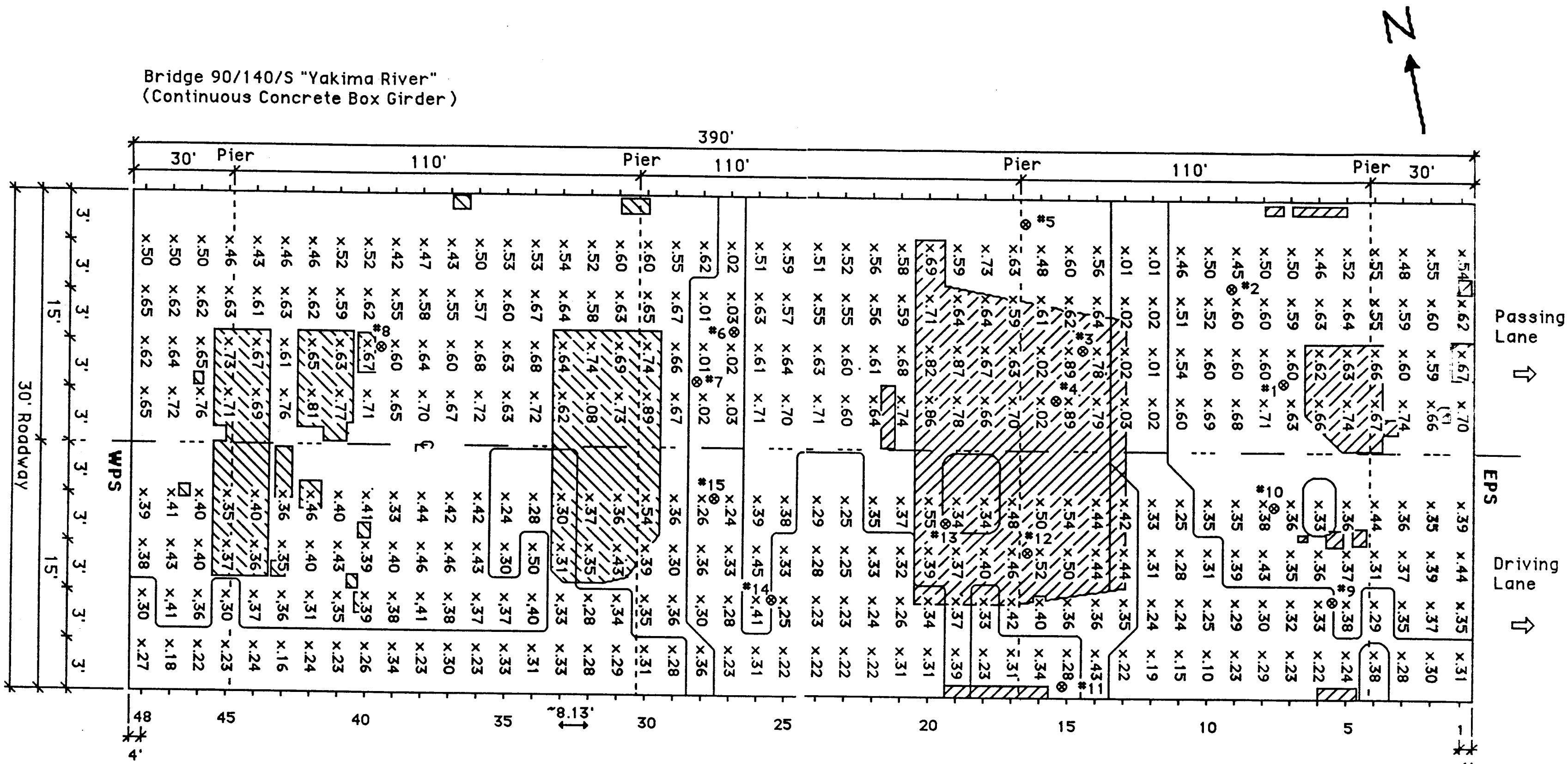
Bridge 90/136 S - continued*

Sample Number	Chloride Content, lb/cy**
1	6.04
2	5.29
3	6.18
4	6.58
5a (1" - 1 3/4" depth)	6.58
5b (1 3/4" - 2 1/2" depth)	8.07
6	3.60
	Driving Lane / Passing Lane
7	2.47
8	2.37
9a (1" - 1 4/5" depth)	6.32
9b (1 4/5" - 2 1/5" depth)	4.80
10	1.98
11	2.03
12	1.34

* Note that the reported longitudinal grid spacing of 8 1/2' is modified to fit the length of the bridge.

** Sampling depth is 1 1/2" - 2" unless otherwise noted.

Bridge 90/140/S "Yakima River"
(Continuous Concrete Box Girder)



Pre-Rehabilitation Data (Summer, 79)

× Half-cell Readings (volts)

⊗ Chloride Test Location

Active Half-Cell Potential Contour

Rehabilitated Areas on Concrete Deck (1979)

Pre-Rehabilitation Chloride/Half-Cell Data and Location of Concrete Repairs on Bridge 90/140 S.

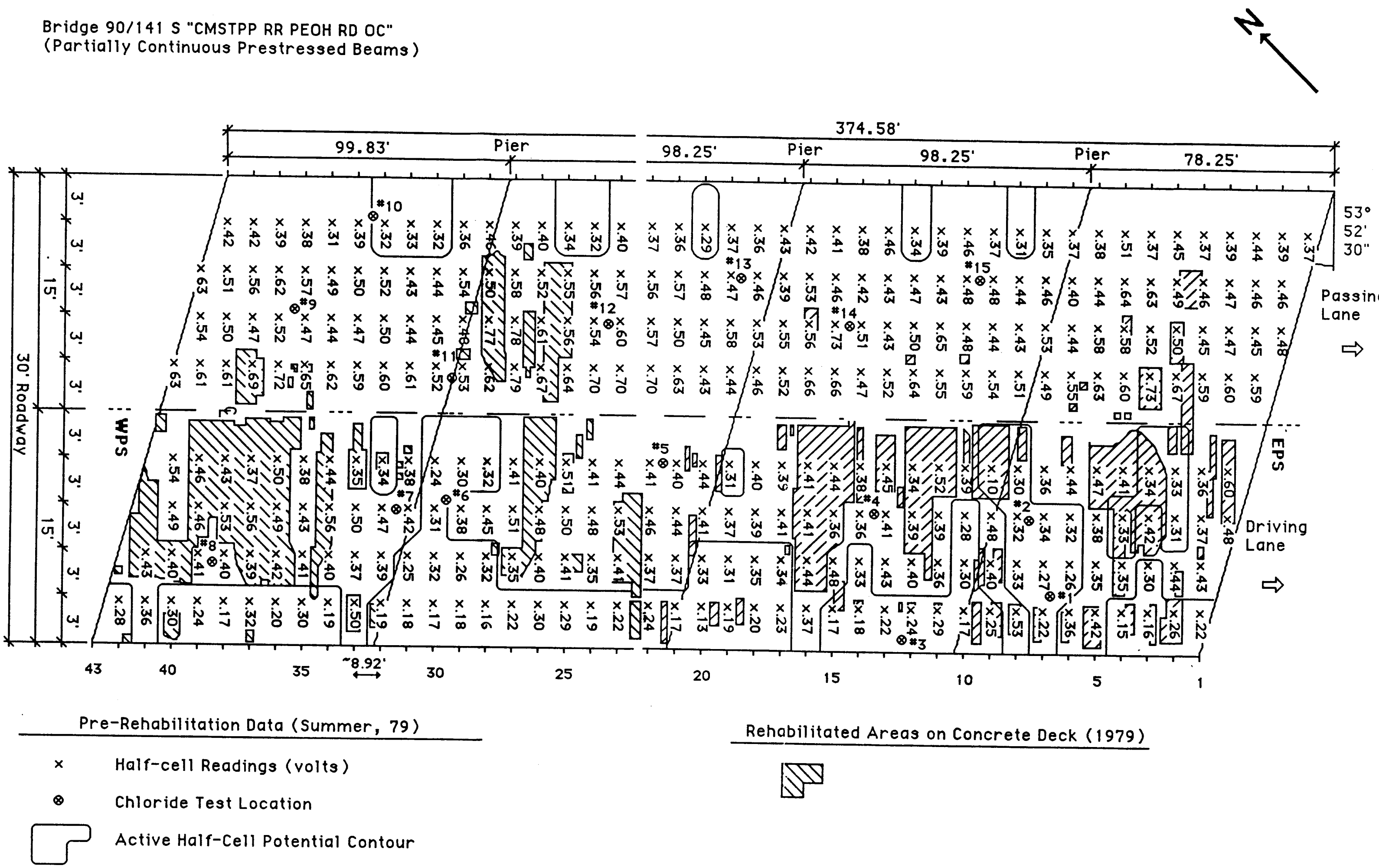
Bridge 90/140 S - continued*

Sample Number	Chloride Content, lb/cy**
1	7.81
2	0.40
3a (1" - 1 3/4" depth)	4.50
3b (1 3/4" - 2 1/4" depth)	3.07
4	6.04
5	1.88
6	9.05
7	7.07
8	0.79
	Passing Lane
	Driving Lane
9	4.55
10a (1" - 1 3/4" depth)	4.30
10b (1 3/4" - 2 1/4" depth)	2.03
10c (2 1/4" - 3" depth)	0.59
11	1.73
12	6.83
13	5.54
14	5.34
15	7.52

* Note that the reported longitudinal grid spacing of 8 1/2' is modified to fit the length of the bridge.

** Sampling depth is 1 1/2" - 2" unless otherwise noted.

Bridge 90/141 S "CMSTPP RR PEOH RD OC"
(Partially Continuous Prestressed Beams)



Pre-Rehabilitation Chloride/Hlaf-Cell Data and Location of Concrete Repairs on Bridge 90/141 S.

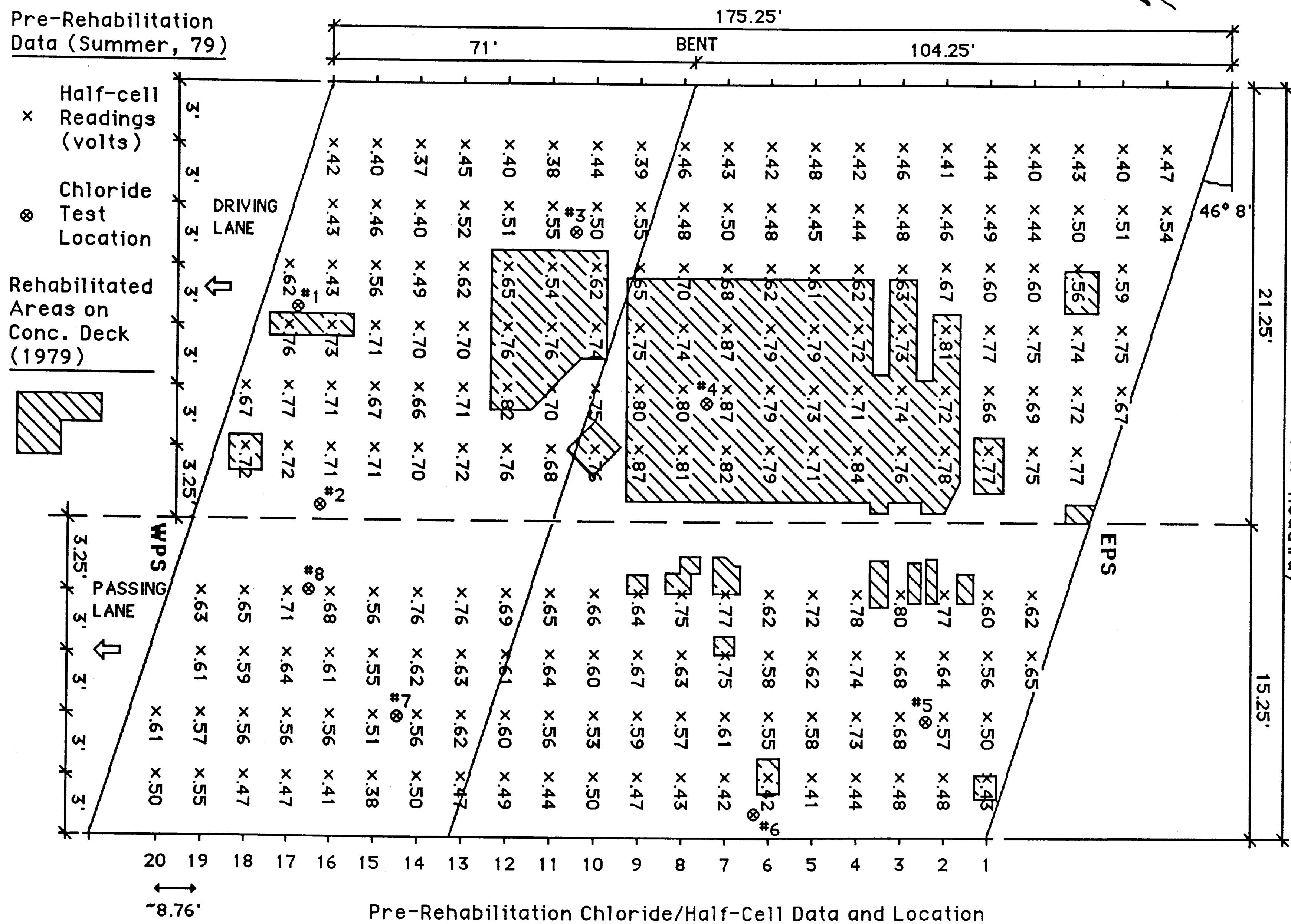
Bridge 90/141 S - continued*

Sample Number	Chloride Content, lb/cy**
1	10.19
2	3.86
3	1.31
4	5.34
5a (3/4 " - 1 1/4" depth)	4.35
5b (1 1/4" - 2 1/4" depth)	2.37
5c (2 1/4" - 3 1/4" depth)	0.89
6	2.03
7	4.75
8	1.39
	Driving Lane / Passing Lane
9	3.02
10	0.89
11	3.81
12a (? depth)	5.29
12b (? depth)	1.14
12c (? depth)	0.79
13	1.09
15	0.49
14	3.37

* Note that the reported longitudinal grid spacing of 8 1/2' is modified to fit the length of the bridge.

** Sampling depth is 1 1/2" - 2" unless otherwise noted.

Bridge 90/145 N "Highline Canal"
(Simple Span Prestressed Conc. Beams)



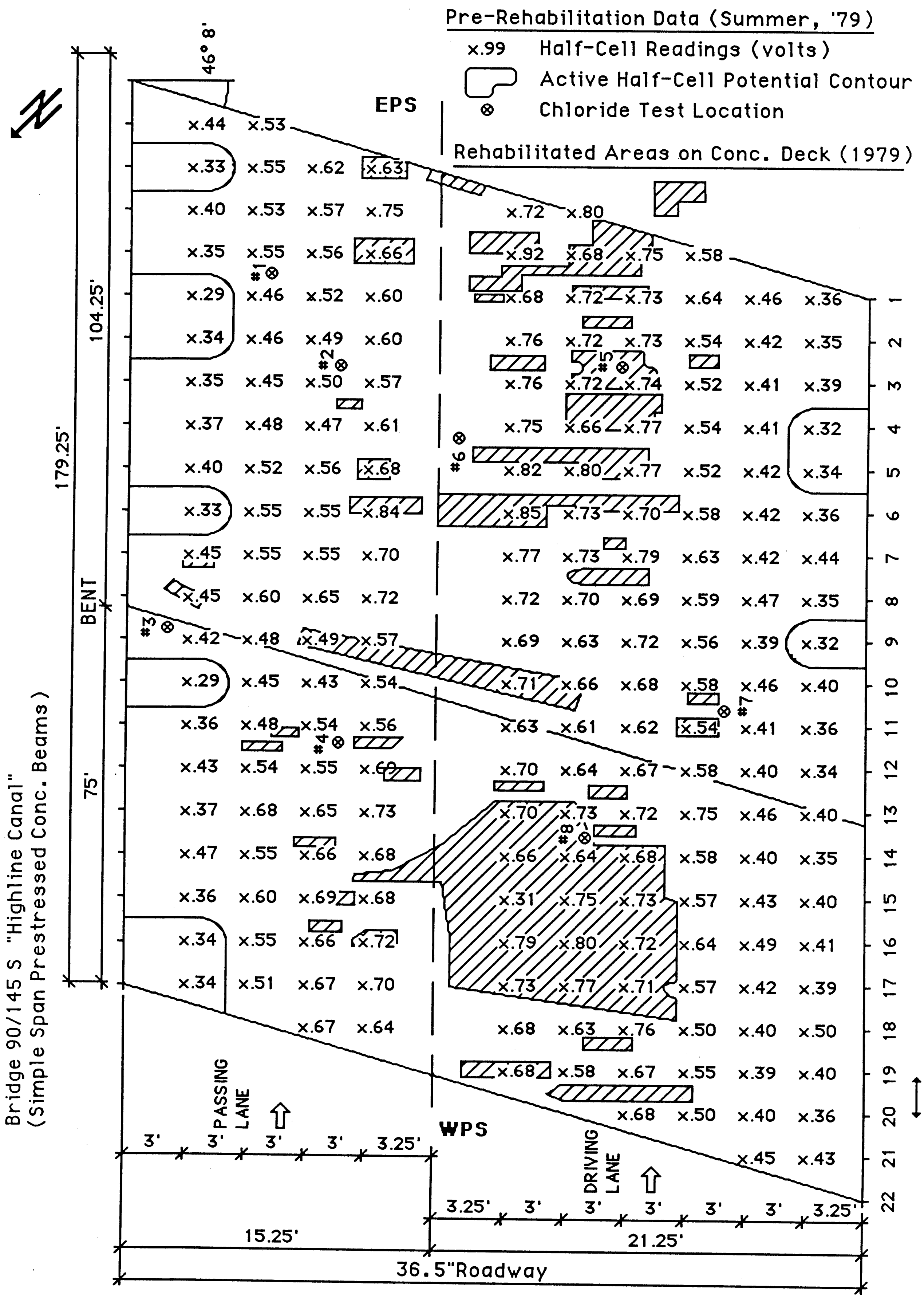
Pre-Rehabilitation Chloride/Half-Cell Data and Location of Concrete Repairs on Bridge 90/145 N.

Bridge 90/145 N - continued*

Sample Number	Chloride Content, lb/cy**
1	4.95
2	2.23
3a (1" - 2" depth)	0.20
3b (2" - 3" depth)	0.20
3c (3" - 4" depth)	0.20
4	6.83
	Driving Lane / Passing Lane
5a (3/4" - 1 1/4" depth)	0.59
5b (1 1/4" - 2 1/4" depth)	0.20
6	0.20
7	0.74
8	6.53

* Note that the reported longitudinal grid spacing of 8 1/2' is modified to fit the length of the bridge.

** Sampling depth is 1 1/2" - 2" unless otherwise noted.



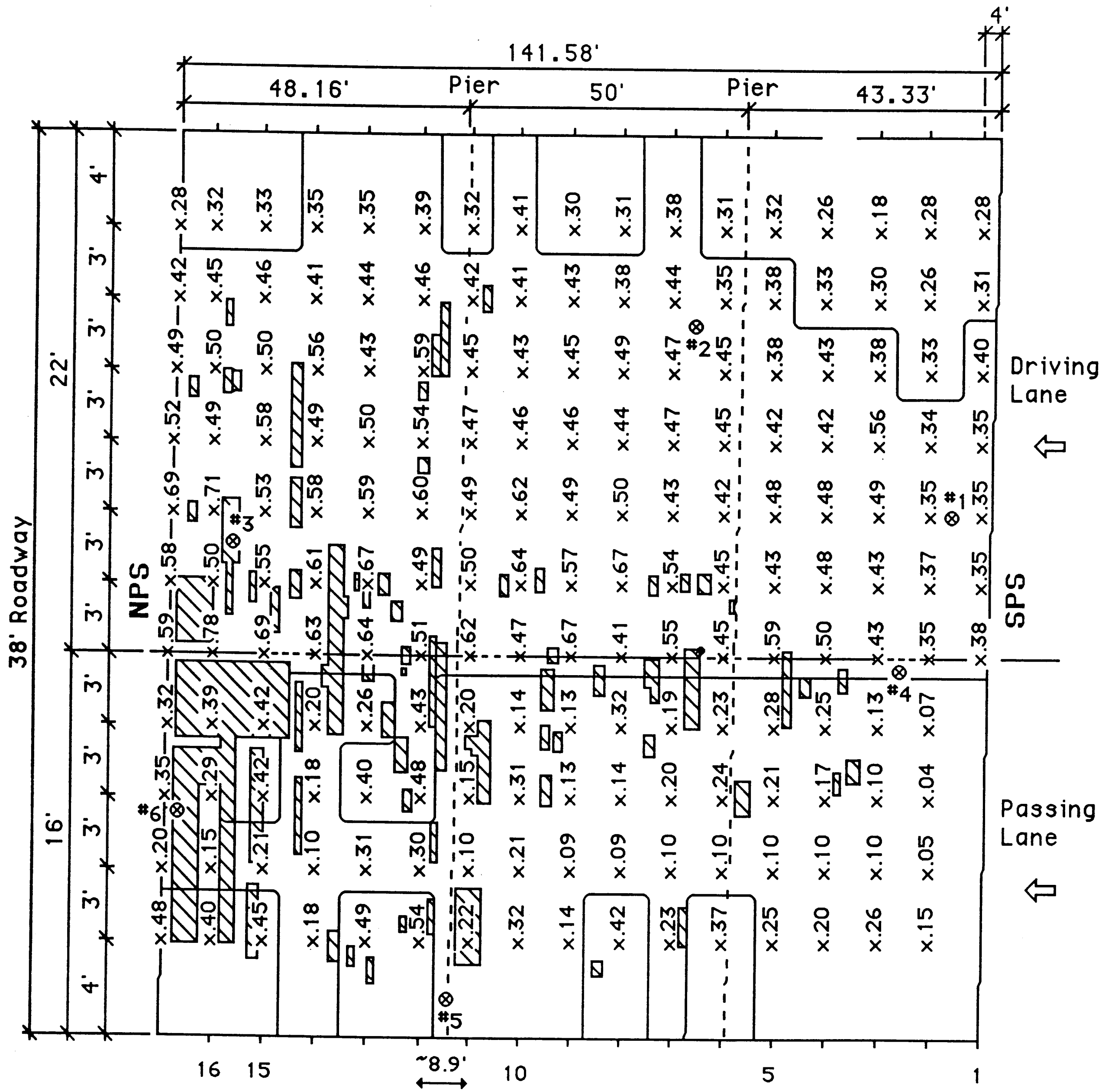
Pre-Rehabilitation Chloride/Half-Cell Data and Location of Concrete Repairs on Bridge 90/145 S.

Bridge 90/145 S - continued*

Sample Number	Chloride Content, lb/cy**
1	0.49
2	0.84
3	0.49
4a (3/4" - 1 1/4" depth)	1.58
4b (1 1/4" - 2 1/4" depth)	0.54
4c (2 1/4" - 2 3/4" depth)	0.25
	Passing Lane
	Driving Lane
5	9.89
6	4.95
7	1.98
8a (3/4 " - 1" depth)	5.74
8b (1" - 1 3/4" depth)	0.99
8c (1 3/4" - 2 1/4" depth)	0.25

* Note that the reported longitudinal grid spacing of 8 1/2' is modified to fit the length of the bridge.

** Sampling depth is 1 1/2" - 2" unless otherwise noted.



Bridge 82/20 N "Squaw Cr R OC"
(Partially continuous prestressed conc. beams)

Pre-Rehabilitation Data (Summer, '79)

x Half-Cell Readings (volts)

⊗ Chloride Test Location

Active Half-Cell Potential Contour

Delamination (Summer, '78)

Pre-Rehabilitation Chloride/Half-Cell/Delamination Data on Bridge 82/20 N.

Bridge 82/20 N - continued*

Sample Number	Chloride Content, lb/cy**
1	4.39
2	3.54
3	5.39
	Driving Lane
	Passing Lane
4	3.70
5	5.89
6	2.54

* Note that the reported longitudinal grid spacing of 8 1/2' is modified to fit the length of the bridge.

** Sampling depth is 1 1/2" - 2" unless otherwise noted.

APPENDIX B

DETAILS OF EXPERIMENT DESIGN

APPENDIX B

EXPERIMENT DESIGN

The following are the activities of the testing program:

A. GRID LAYOUT

Repeat the original grid pattern used in pre-rehabilitation testing for each site for easier comparison of "before" and "after" data.

B. CHAIN DRAGGING

Chain drag the AC to find possible delaminations or debonding. Map and outline the areas of distress.

C. LOCATION OF CORES

Lay out the core locations on the test lane as indicated in Table B-1. Adjustments, however, may be made in the field for the most appropriate location. Also, distribute more core locations on the distressed areas, as indicated by chain dragging or other means, until the total number of cores are 18, 15, 10, 10 and 10 for bridges 90/135 S, 90/140 S, 90/145 N, 90/145 S, and 82/20 S, respectively.

D. PRE-WETTING CORE LOCATIONS

Pre-wet the core locations by spraying water mixed with a wetting agent and dye. Repeat the wetting of the sites in series to allow ample time for the moisture to penetrate. Also, pre-wet the electrical resistivity test sites as explained in item G.

E. VISUAL INSPECTION

Map and photograph the AC surface condition, including cracks of all types, raveling, patching, etc. When possible, record and photograph the deck from below to reveal conditions such as cracks, seepage, efflorescence, spalling, etc.

Table B-1. Layout of Core Locations

Bridge No. \ Core No. (Coordinates*)	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16	
	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y	x	y
90/136 S (Passing Lane)	32+	7.5	81+	7.5	98	10.5	116	3	120°	9	146°	6	163	10.5	210	3	240	10.5	270°	9	304	6	309+	10.5	317+	2	364	3	386+	10.5		
90/140 S (Passing Lane)	57+	11	69+	5	126°	10.5	130+	2	146°	10.5	215+	8	224+	10.5	252°	10.5	297	9	313+	9	358°	10.5	378	6								
90/145 N (Driving Lane)	35	12	53	3	79°	15	96°	15	123+	6	175+	18	184+	9																		
90/145 S (Passing Lane)	38+	6	56+	10	77	3	77	11	111+	3	132+	10	162	9																		
82/20 N (Driving Lane)	14+	16	22	4	53+	8.5	84	16	120	4	128+	16	138°	18																		

* x (ft) is measured from EPS or SPS, whichever applies
y (ft) is measured from the curb

+ Location of pre-reconstruction chloride sampling
° Location on patch

F. <u>EXPOSE REBAR FOR GROUND</u>

Provide a ground for the electrical resistivity and half- cell tests by exposing the rebar. The number of grounds will depend on the number of joints and the continuity of the rebar and length of the bridge deck. Use the data form given in Figure B-1 to record the necessary data.

G. <u>ELECTRICAL RESISTIVITY TESTING</u>

Conduct the electrical resistivity tests in accordance with astm D3633 using the grid pattern with a minimum of 5' between the adjacent test sites and 2' between a test site and the curb.

H. <u>CORING OPERATION AND ASSOCIATED TESTS</u>

Obtain core samples through the AC and the membrane by dry coring at the locations determined for this purpose (see item C). If the concrete is to be cored, the core location should be chosen to avoid drilling through the rebar. Clean the remainder of the membrane from the concrete if some of the membrane is left in place. Conduct the tests as follows and record the information on the data form given in Figure B-2.

1. Determine the bonding and waterproofing properties of the AC/membrane system by visually inspecting it.
2. Conduct half-cell tests on the exposed concrete in accordance with ASTM C876.
3. Conduct a pachometer survey on the AC and measure the thickness of the AC/membrane system to find the concrete cover thickness.
4. Visually inspect and sound the exposed concrete surface(sounding in this case may not necessarily reveal distress).
5. Core the concrete in the locations determined for this purpose and inspect any distress in the cored sample.

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date:

Bridge No.:

Weather Condition:

Ground No.:

<u>Ground</u> <u>Location</u>

Distance from curb, ft:

Relevant longitudinal grid no.:

Pachometer reading conducted over AC	
Converted pachometer depth conducted over AC, in. (a)	
Measured AC/membrane thickness, in.	
Actual rebar depth measured from AC surface, in. (b)	
Average correction for every inch depth measured by pachometer over AC, in. $(\frac{b-a}{a})$	

Figure B-1. Data Form for Ground

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date:

Bridge No.:

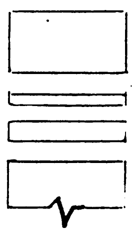
Weather Condition:

Core No.: Defective as sounded by chain over AC: ____ Yes ____ No

Core Location

Distance from curb, ft.

Relevant longitudinal grid no.:



	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	←	←	←
Fabric	← ←	← ←	← ←
Rubber-Asphalt	←	←	←
Concrete	←	←	←

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: ____ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: ____ Sound ____ Delaminated

General Comments:

Figure B-2. Data Form for Coring Operation

Bridge No.:

Core No.:

Half-cell reading, v		
Pachometer conducted over AC	Reading	
	Converted rebar depth, in.	
	Adjusted rebar depth, in. (a)	
Measured AC/membrane thickness, in. (b)		
Concrete cover thickness, in. (a-b)		

Drawing and comments on distress in concrete if cored:

Figure B-2. Data Form for Coring Operation (Continued)

I. WATER CONTENT DETERMINATION

Select two core locations on each bridge, preferably those with signs of water penetration. Take powdered concrete samples from a depth of 1/4" - 1-1/2" at each location and keep the sample in a container so that the moisture in the sample will not evaporate. Determine the percent of water content by weighing the sample wet and dry and dividing the difference by the dry weight.

J. CHLORIDE CONTENT DETERMINATION

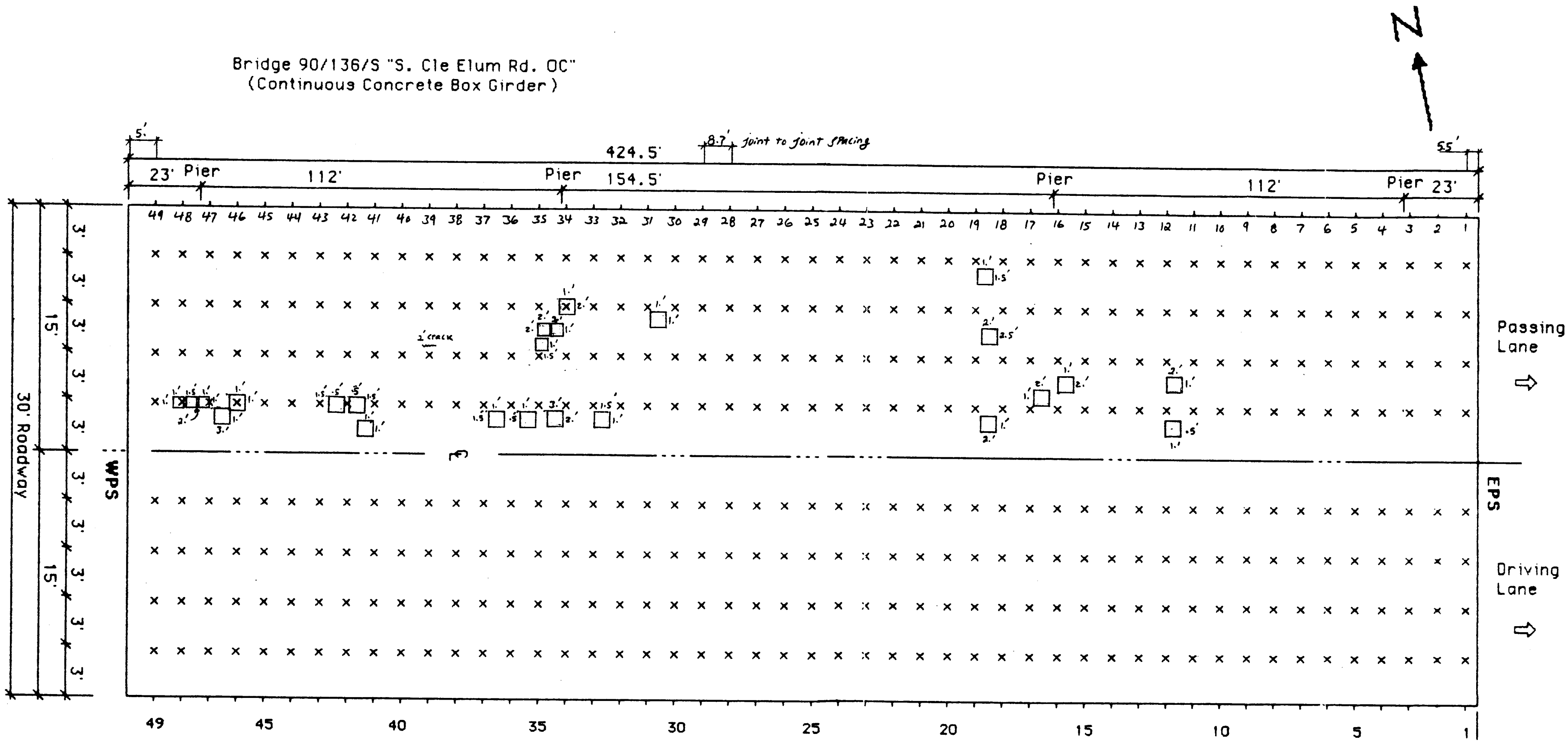
1. Resample the concrete for chloride content in the relevant core locations (see Table B-1) using the same depth (see Appendix A). On bridge 82/20 N, however, sample concrete at 0 - 1/2", 1/2" - 1", 1" - 1-1/2", and 1-1/2" - 2" at each previous chloride test location. This is to determine the nature of the sampled concrete (if it is original concrete or patch concrete) before comparing the results with "before" condition data.
2. On the cored areas known to be located on patches (see Table B-1) sample the concrete at 0 - 1/2", 1/2" - 1", and 1" - 1-1/2" for chloride content determination. On the driving lane of bridge 90/145 S, take chloride samples in the concrete from two locations known to be patches (120 ft. from EPS and 15 and 18 ft. from the curb) at depths of 0 - 1/2", 1/2" - 1" and 1" - 1-1/2".

APPENDIX C

STUDIES' RAW DATA COLLECTED IN FIELD AND LABORATORY

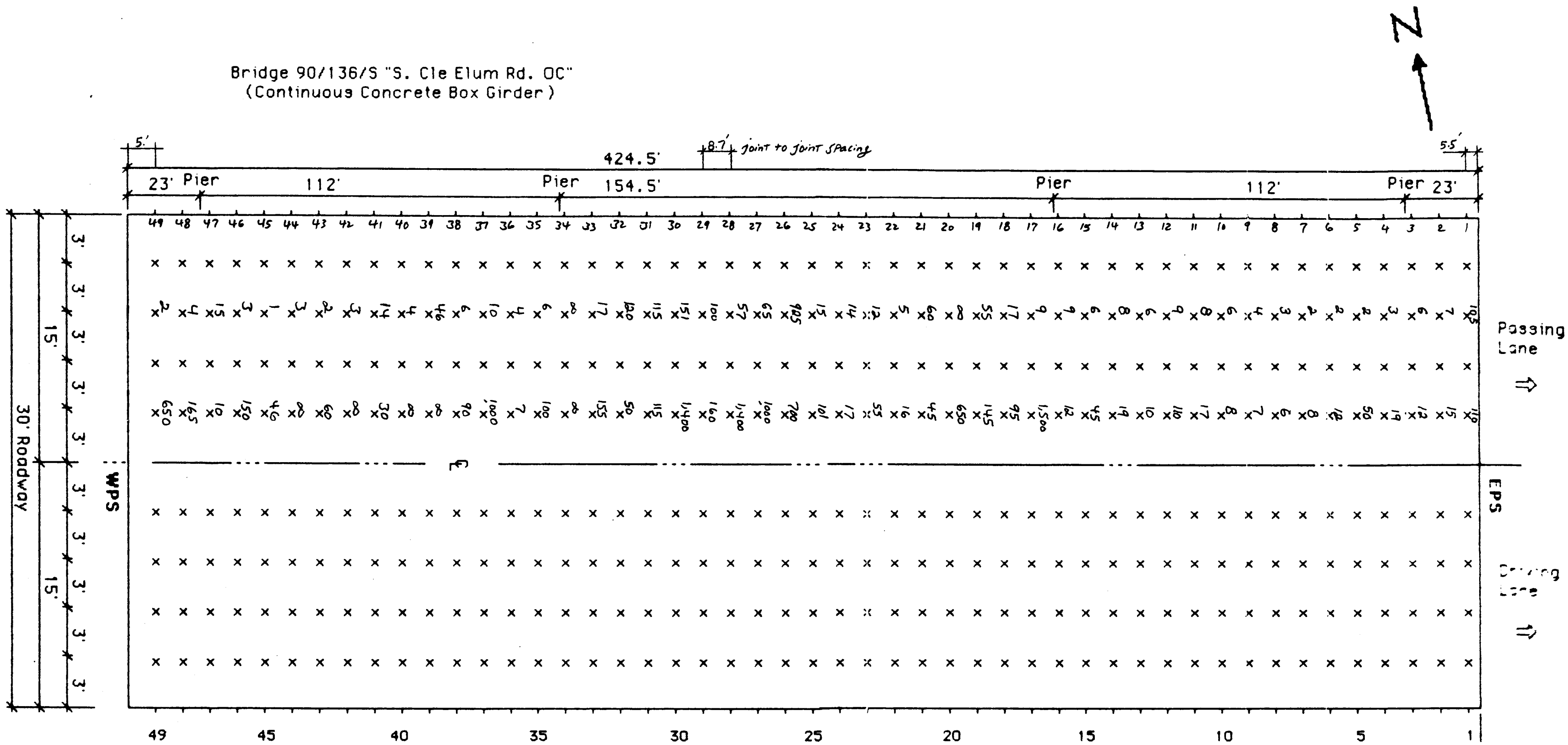
COLLECTED DATA ON BRIDGE 90/136 S

Bridge 90/136/S "S. Cle Elum Rd. OC"
(Continuous Concrete Box Girder)

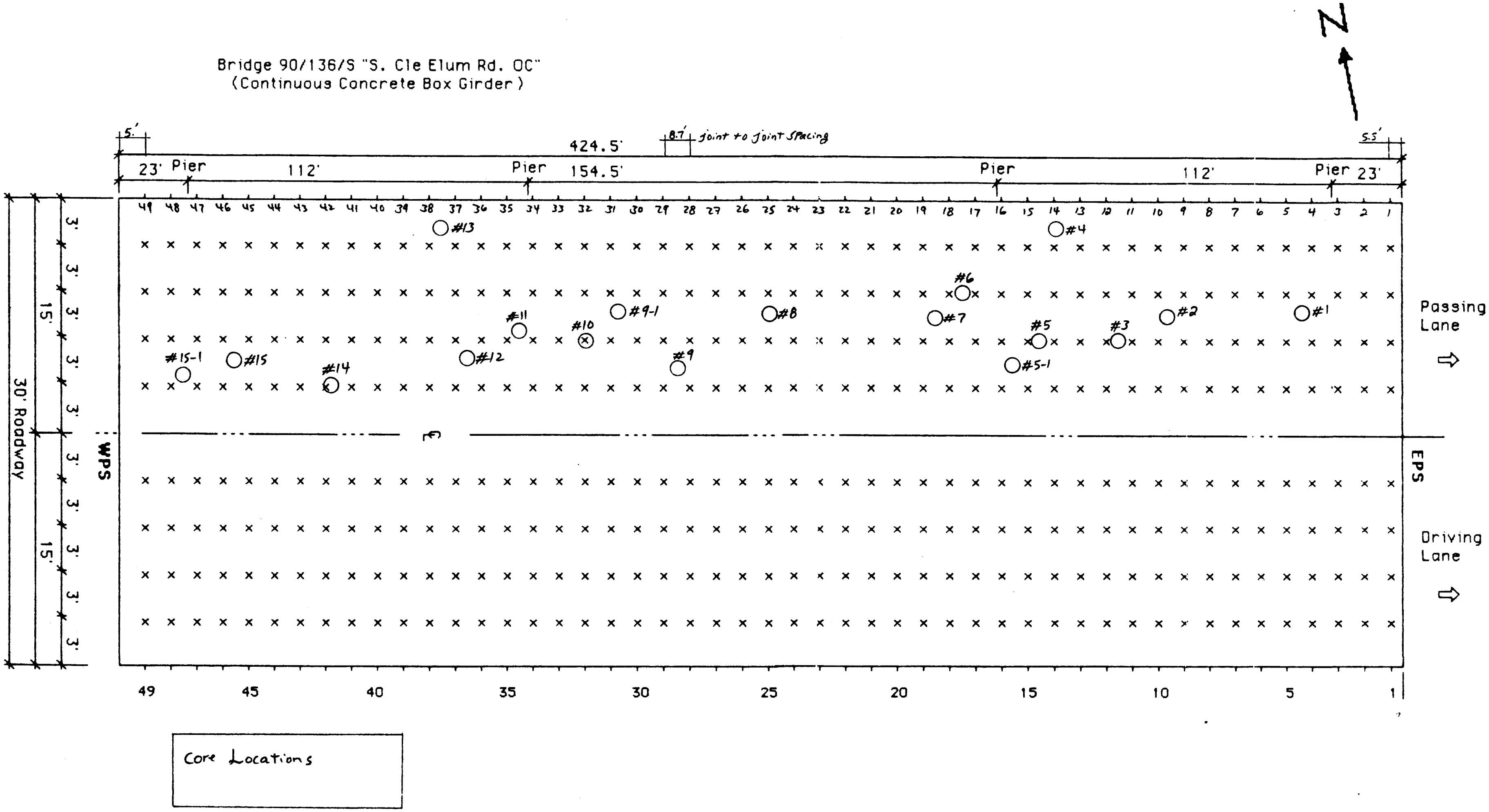


Defective areas as indicated by chain dragging AC.
5-23-85

Bridge 90/136/S "S. Cle Elum Rd. OC"
(Continuous Concrete Box Girder)



Electrical Resistivity on AC
(1000 Ohms)
5-23-85


Bridge 90/136/S "S. Cle Elum Rd. OC"
(Continuous Concrete Box Girder)
N
424.5'
8.7' joint to joint spacing
5'
5.5'
23' Pier 112' Pier 154.5' Pier 112' Pier 23'
Passing Lane
Driving Lane
EPS
WPS
#1 #2 #3 #4 #5 #5-1 #6 #7 #8 #9 #9-1 #10 #11 #12 #13 #14 #15 #15-1
49 45 40 35 30 25 20 15 10 5 1
3' 3' 3' 3' 3' 3' 3' 3' 3' 3'
15' 15'
30' Roadway
Core Locations

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-28-85

Bridge No.: 90/136 S

Weather Condition: Partly sunny, 60°s F

Ground No.: 1

Ground Location

Distance from curb, ft: 3'

Relevant longitudinal grid no.: No. 21+1'

Pachometer reading conducted over AC	34
Converted pachometer depth conducted over AC, in. (a)	2.5"
Measured AC/membrane thickness, in.	1.8"
Actual rebar depth measured from AC surface, in. (b)	3.5"
Average correction for every inch depth measured by pachometer over AC, in. $(\frac{b-a}{a})$	0.40 "/"

Actual conc. cover = 1.7"

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-28-85

Bridge No.: 90/136 S

Weather Condition: Partly Sunny, 60°F

Core No.: 1

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 8'

Relevant longitudinal grid no.: No. 4 + 3'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC / Fabric	√L	√M →	
Rubber-Asphalt / Concrete	√L	√L →	

CL lb/c.y. Pre-	Post-	Depth
2.47	1.37	1½"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

L bond between membrane and concrete in this case indicates that membrane was peeled off by hand.

→ Indicate slightly toward the adjacent category.

Half-cell reading, v		-.112
Pachometer conducted over AC	Reading	33
	Converted rebar depth, in.	2.5"
	Adjusted rebar depth, in. (a)	3.5"
Measured AC/membrane thickness, in. (b)		2"
Concrete cover thickness, in. (a-b)		1.5"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-28-85

Bridge No.: 90/136 S

Weather Condition: Partly sunny, 60's F

Core No.: 2

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 7.5'

Relevant longitudinal grid no.: NO. 10-1.5'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	↑		
Fabric	√L	√M →	
Rubber-Asphalt	√M		
Concrete			

CL lb/c.y. Pre-	Post-	Depth
2.37	3.74	1½"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.170
Pachometer conducted over AC	Reading	31
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	3.64"
Measured AC/membrane thickness, in. (b)		1.65"
Concrete cover thickness, in. (a-b)		1.99"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-28-85

Bridge No.: 90/136 S

Weather Condition: Partly sunny, 60s °F

Core No.: 3

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 9'

Relevant longitudinal grid no.: NO.12-1.5'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√L	√H →	
Fabric			
Rubber-Asphalt	√L		
Concrete			

Moisture, wt% Post-	Depth
2.7	1/4"-1 1/2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: ____ Sound X Delaminated

General Comments:

Half-cell reading, v		-.273
Pachometer conducted over AC	Reading	33
	Converted rebar depth, in.	2.5"
	Adjusted rebar depth, in. (a)	3.5
Measured AC/membrane thickness, in. (b)		1.8"
Concrete cover thickness, in. (a-b)		1.7"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-28-85

Bridge No.: 90/136 S

Weather Condition: Partly Sunny, 60°F

Core No.: 4

Defective as sounded by chain over AC: ____ Yes _X_ No

Core Location

Distance from curb, ft.

Relevant longitudinal grid no.:

Layer	Bond[c]	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	√H		√M
Rubber-Asphalt	√M		
Concrete			

[c] Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: _X_ Sound ____ Delaminated

General Comments:

Two membranes overlapped in the core location.

Half-cell reading, v		-.148
Pachometer conducted over AC	Reading	30
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	3.64"
Measured AC/membrane thickness, in. (b)		1.85"
Concrete cover thickness, in. (a-b)		1.79"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-28-85

Bridge No.: 90/136 S

Weather Condition: Partly sunny, 60°s F

Core No.: 5

Defective as sounded by chain over AC: ___ Yes _X_ No

Core Location

Distance from curb, ft. 9'

Relevant longitudinal grid no.: NO. 15 - 3.5'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√L	√L →	
Fabric			
Rubber-Asphalt	√L		
Concrete			

CL, lb/c.y. Pre-	Post-	Depth
	12.50	0-½"
	7.63	½"-1"
	5.64	1"-1½"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: _X_ Sound ___ Delaminated

General Comments:

According to the background information the core is located on a patch. However the color of concrete in the hole drilled for Cl is gray like normal PC concrete and not brownish and dark like the typical patch concrete used on these bridges.

Half-cell reading, v		-.206
Pachometer conducted over AC	Reading	36
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.36"
Measured AC/membrane thickness, in. (b)		1.8"
Concrete cover thickness, in. (a-b)		1.56"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-28-85

Bridge No.: 90/136 S

Weather Condition: Partly Sunny, 60°s F

Core No.: 5-1

Defective as sounded by chain over AC: X Yes ___ No

Core Location

Distance from curb, ft. 10'

Relevant longitudinal grid no.: No.16-2'

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	√L	√M	
Rubber-Asphalt	√L		
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: ___ Sound X Delaminated

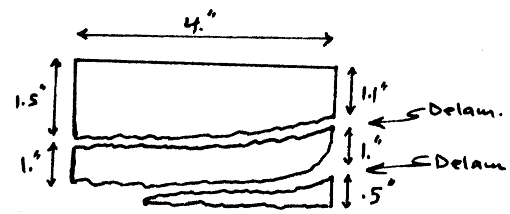
General Comments:

Half-cell reading, v		-.320
Pachometer conducted over AC	Reading	35
	Converted rebar depth, in.	2.5"
	Adjusted rebar depth, in. (a)	3.5"
Measured AC/membrane thickness, in. (b)		1.8"
Concrete cover thickness, in. (a-b)		1.7"

Drawing and comments on distress in concrete if cored:

Concrete cored:

The nature of concrete is original. Two layers of delaminations were detected in the core sample which become free after drilling the Perimeter of the core. The delaminated concrete came out in the coring bore.



Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-28-85

Bridge No.: 90/136 S

Weather Condition: Partly sunny, 60's F

Core No.: 6

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 6'

Relevant longitudinal grid no.: No. 17+4.5'

	Bond°	Moisture Presence+	Dyed Moisture Presence+	CL, lb/c.y. Pre-	Post-	Depth
AC	√L					
Fabric					7.43	0-½"
Rubber-Asphalt	√L				8.51	½"-1"
Concrete					4.15	1"-1½"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

According to the background information the core is located on a patch. However, the appearance of the concrete as seen in the hole drilled for Cl is questionable (i.e., original or patch).

Half-cell reading, v		-.205
Pachometer conducted over AC	Reading	39
	Converted rebar depth, in.	2.3"
	Adjusted rebar depth, in. (a)	3.22"
Measured AC/membrane thickness, in. (b)		1.65"
Concrete cover thickness, in. (a-b)		1.57"

Drawing and comments on distress in concrete if cored: ____________________

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-28-85

Bridge No.: 90/136 S

Weather Condition: Partly sunny, 60°s F

Core No.: 7

Defective as sounded by chain over AC: X Yes ___ No

Core Location

Distance from curb, ft. 7.5'

Relevant longitudinal grid no.: NO.18+2'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+	CL, lb/c.y. Pre-	Post-	Depth
AC						
Fabric	√L		√L	6.32	5.34	1"-1 4/5"
Rubber-Asphalt	√H			4.80	2.51	1 4/5"-2 1/5"
Concrete						

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: ___ Sound X Delaminated

General Comments:

the plane of delamination could be seen in the hole drilled for Cl in the concrete. It is about 0.5" below concrete surface and is mainly toward EPS.

Half-cell reading, v		-.431
Pachometer conducted over AC	Reading	40
	Converted rebar depth, in.	2.3"
	Adjusted rebar depth, in. (a)	3.22"
Measured AC/membrane thickness, in. (b)		1.65"
Concrete cover thickness, in. (a-b)		1.57"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-28-85

Bridge No.: 90/136 S

Weather Condition: Partly sunny, 60s °F

Core No.: 8

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 8'

Relevant longitudinal grid no.: No. 25

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric			
Rubber-Asphalt	√H		
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.126
Pachometer conducted over AC	Reading	36
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.36"
Measured AC/membrane thickness, in. (b)		1.65"
Concrete cover thickness, in. (a-b)		1.71"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-28-85

Bridge No.: 90/136 S

Weather Condition: Partly sunny, 60's F

Core No.: 9

Defective as sounded by chain over AC: X Yes ___ No

Core Location

Distance from curb, ft. 10.5'

Relevant longitudinal grid no.: NO.28+4'

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	↑		
(AC/Fabric)	√L	√L	
Fabric			
Rubber-Asphalt			
(Rubber-Asphalt/Concrete)	√L		
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: ___ Sound X Delaminated

General Comments:

Half-cell reading, v		-.190
Pachometer conducted over AC	Reading	37
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.36"
Measured AC/membrane thickness, in. (b)		2.1"
Concrete cover thickness, in. (a-b)		1.26"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-28-85

Bridge No.: 90/136 S

Weather Condition: Partly Sunny, 60's F

Core No.: 9-1

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 7'

Relevant longitudinal grid no.: No. 31 - 1'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√L	√M	
Fabric			
Rubber-Asphalt	√M		
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: ____ Sound X Delaminated

General Comments:

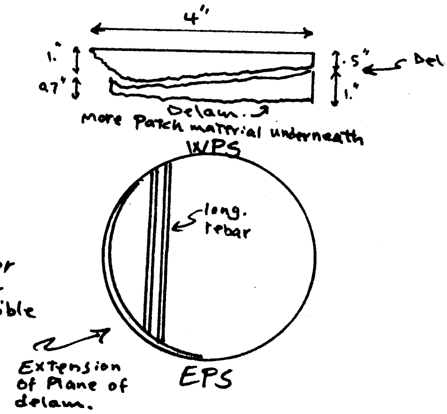
concrete surface appearance suggests patch material.

Half-cell reading, v		-.248
Pachometer conducted over AC	Reading	39
	Converted rebar depth, in.	2.3"
	Adjusted rebar depth, in. (a)	3.22"
Measured AC/membrane thickness, in. (b)		1.6"
Concrete cover thickness, in. (a-b)		1.62"

Drawing and comments on distress in concrete if cored:

Concrete Cored;

the concrete's nature is Patch, darker in color (brownish) and with finer aggregate. the delaminated Part was freed while coring and came in the coring bore. two Planes of delaminations can be detected. More Patch material is left in Place indicating delaminations not debonding. the Patch material looks inferior in quality and strength. After the remainder of the concrete in place was chiseled out, Two longitudinal rebar could be seen in the core location. No corrosion on the long. rebar could be visually detected. Extension of the Plane of delam is visible in the circumference of the core.



Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-29-85

Bridge No.: 90/136S

Weather Condition: Partly cloudy, 60°SF

Core No.: 10

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 9'

Relevant longitudinal grid no.: No. 32

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	← √L	← √M	←
Fabric	←	←	←
Rubber-Asphalt	← √H	←	←
Concrete	←	←	←

CL, lb/c.y.

Pre-	Post-	Depth
	0.20	0-½"
	0.25	½"-1"
	0.30	1"-1½"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

concrete surface appearance patch material, dark brownish in color.

Half-cell reading, v		-.141
Pachometer conducted over AC	Reading	39
	Converted rebar depth, in.	2.3"
	Adjusted rebar depth, in. (a)	3.22"
Measured AC/membrane thickness, in. (b)		2.0"
Concrete cover thickness, in. (a-b)		1.22"

Drawing and comments on distress in concrete if cored: ______

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-29-85

Bridge No.: 90/136 S

Weather Condition: Partly cloudy, 60°F

Core No.: 11

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 8'

Relevant longitudinal grid no.: No. 35- 3.5'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	↑ √L	√L	
Rubber-Asphalt	√L	√L	
Concrete			

Moisture, wt %

Past-	Depth
4.8	1/4"-1 1/2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

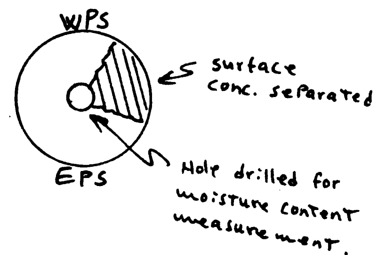
+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: ____ Sound X Delaminated

General Comments:

A 0.5" thick surface layer of concrete was partially separated in the core location next to the hole drilled in the concrete for moisture content.



Half-cell reading, v		-.284
Pachometer conducted over AC	Reading	43
	Converted rebar depth, in.	2.2"
	Adjusted rebar depth, in. (a)	3.08"
Measured AC/membrane thickness, in. (b)		1.8"
Concrete cover thickness, in. (a-b)		1.28"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-29-85

Bridge No.: 90/136S

Weather Condition: Partly cloudy, 60's F

Core No.: 12

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 16'

Relevant longitudinal grid no.: NO.37-3.5'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	√L	√L	
Rubber-Asphalt	√L	√L	
Concrete			

$\bar{CL}$, lb/c.y.

Pre-	Post-	Depth
1.98	0.71	1½"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.268
Pachometer conducted over AC	Reading	25
	Converted rebar depth, in.	2.8"
	Adjusted rebar depth, in. (a)	3.92"
Measured AC/membrane thickness, in. (b)		2.3"
Concrete cover thickness, in. (a-b)		1.62"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-29-85

Bridge No.: 90/136 S

Weather Condition: Partly cloudy, 60°F

Core No.: 13

Defective as sounded by chain over AC: ___ Yes X No

Core Location

Distance from curb, ft. 2'

Relevant longitudinal grid no.: No. 37+4'

	Bond[a]	Moisture Presence+	Dyed Moisture Presence+
AC	↑		
Fabric	√L	√M	
Rubber-Asphalt	√H		
Concrete			

CL, lb/c.y. Pre-	Post-	Depth
2.03	1.19	1½"-2"

[a] Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: X Sound ___ Delaminated

General Comments:

Half-cell reading, v		-.154
Pachometer conducted over AC	Reading	22
	Converted rebar depth, in.	2.9"
	Adjusted rebar depth, in. (a)	4.06
Measured AC/membrane thickness, in. (b)		2.85"
Concrete cover thickness, in. (a-b)		1.21"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-29-85

Bridge No.: 90/136 S

Weather Condition: Partly cloudy, 60° F

Core No.: 14

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 11'

Relevant longitudinal grid no.: NO. 42 -1'

	Bond*	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	√L	√M	
Rubber-Asphalt	√L	√M	
Concrete			

* Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

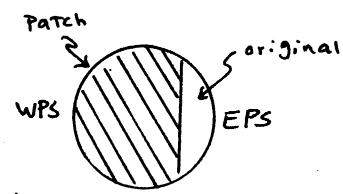
\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: ____ Sound X Delaminated

General Comments:

Concrete appearance dark brownish like Patch material Toward WPS. toward EPS original concrete.

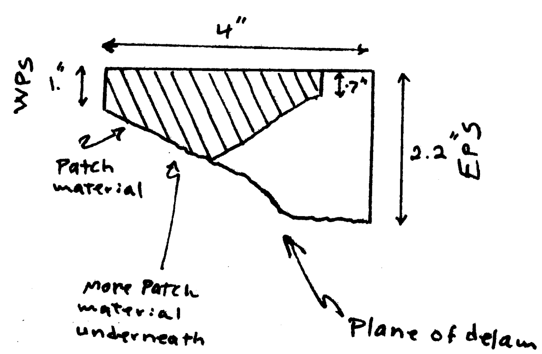


Half-cell reading, v		-.397
Pachometer conducted over AC	Reading	28
	Converted rebar depth, in.	2.5"
	Adjusted rebar depth, in. (a)	3.5"
Measured AC/membrane thickness, in. (b)		1.5"
Concrete cover thickness, in. (a-b)		2"

Drawing and comments on distress in concrete if cored:

Concrete cored:

the delaminated was Freed while drilling and came out in The coring bore. the Plane of delam extends from the original concrete into the Patch getting closer To the surface.



Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-29-85

Bridge No.: 90/136 S

Weather Condition: Partly cloudy, 60's F

Core No.: 15

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 10'

Relevant longitudinal grid no.: No. 46 - 4'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	✓L	✓H	
Fabric			
Rubber-Asphalt	✓H	✓L	
Concrete			

$\overline{CL}$, lb/c.y. Pre-	Post-	Depth
1.34	0.59	1½"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.238
Pachometer conducted over AC	Reading	30
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.36"
Measured AC/membrane thickness, in. (b)		1.25"
Concrete cover thickness, in. (a-b)		2.11"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-29-85

Bridge No.: 90/136 S

Weather Condition: Partly cloudy, 60°F

Core No.: 15-1

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 12'

Relevant longitudinal grid no.: No. 47 + 5'

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	← √L	← √M	←
Fabric	←	←	←
Rubber-Asphalt	← √L	← √M	←
Concrete	←	←	←

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: ____ Sound X Delaminated

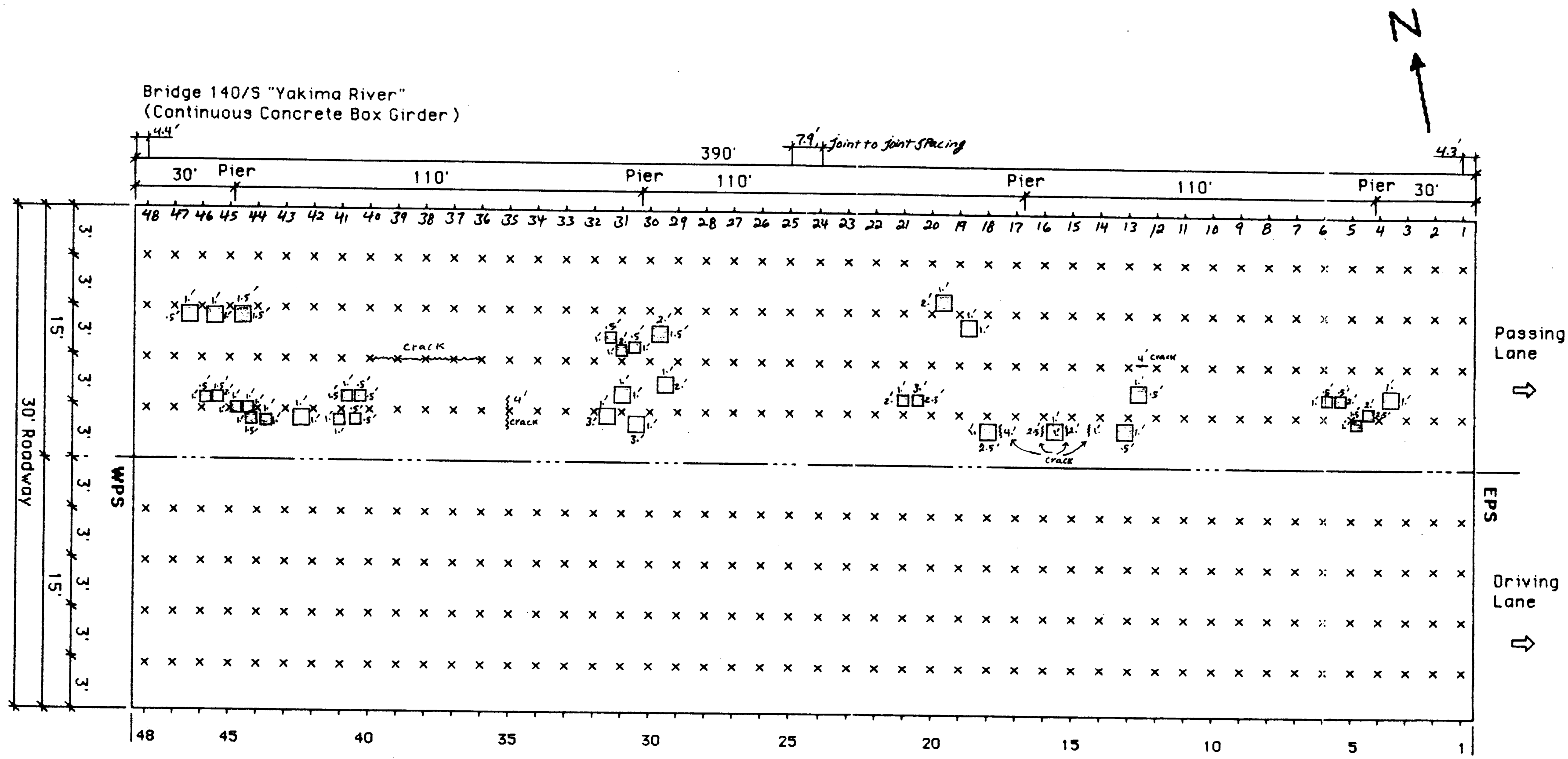
General Comments:

Half-cell reading, v		-.369
Pachometer conducted over AC	Reading	37
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.36"
Measured AC/membrane thickness, in. (b)		1.65"
Concrete cover thickness, in. (a-b)		1.71"

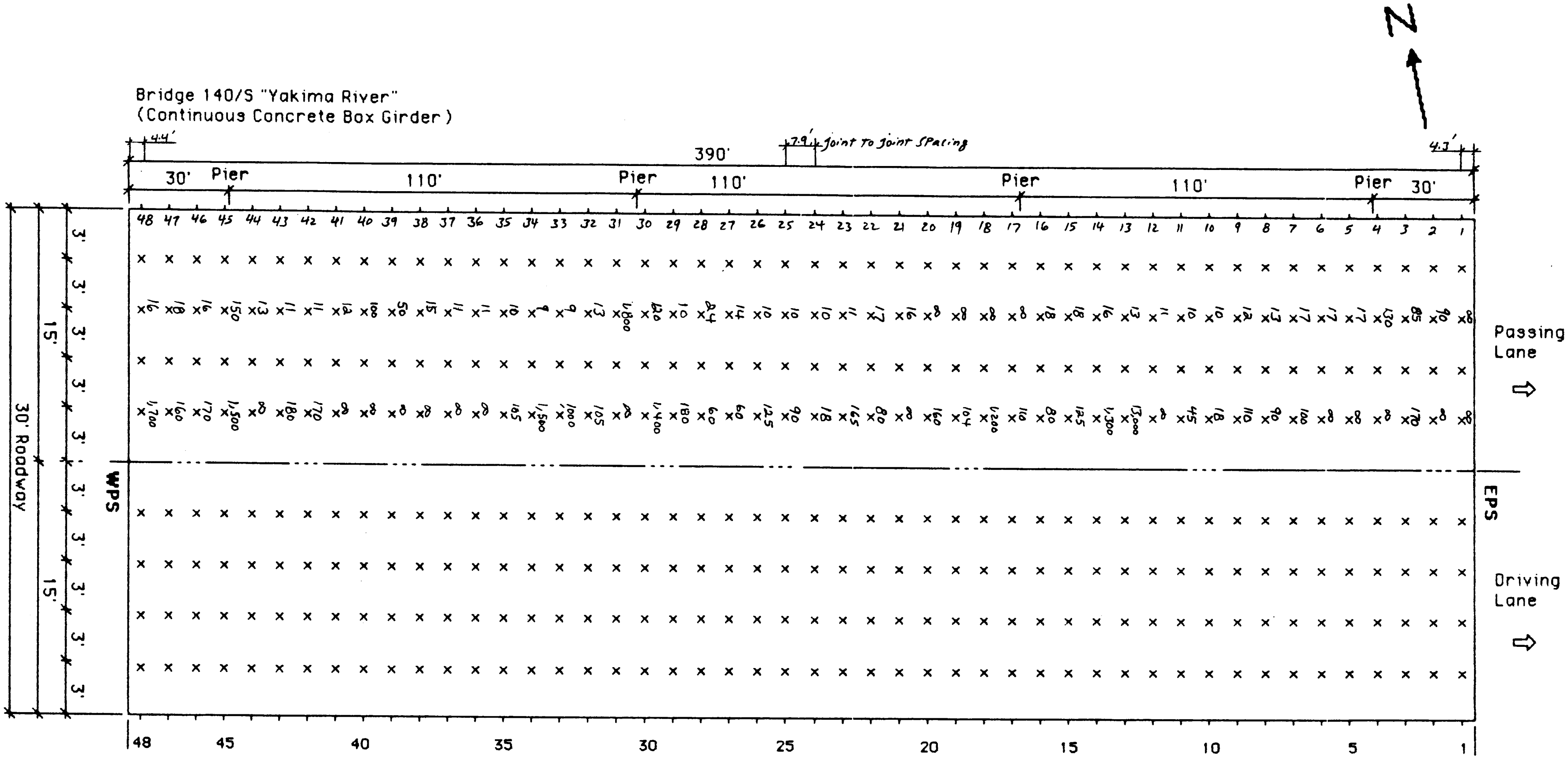
Drawing and comments on distress in concrete if cored:

COLLECTED DATA ON BRIDGE 90/140 S

Bridge 140/S "Yakima River"
(Continuous Concrete Box Girder)

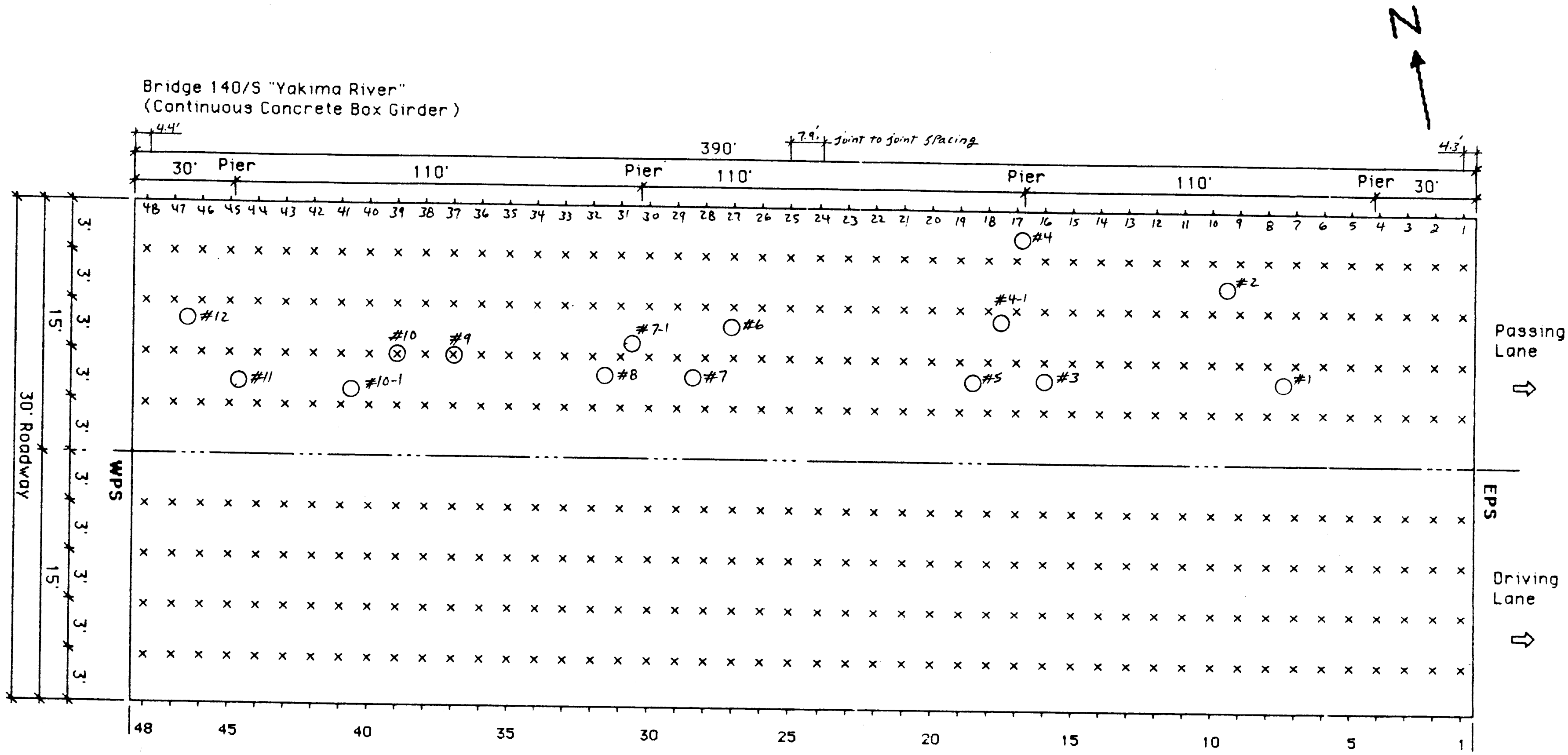


Defective areas as indicated
by chain dragging AC
5-29-85



Electrical Resistivity on AC
(1000 Ohms)
5-29-85

Bridge 140/S "Yakima River"
(Continuous Concrete Box Girder)



Core Locations

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/140 S

Weather Condition: Partly cloudy, 60°SF

Ground No.: 1

Ground Location

Distance from curb, ft: 3'

Relevant longitudinal grid no.: No. 25+2.5'

Pachometer reading conducted over AC	28
Converted pachometer depth conducted over AC, in. (a)	2.6"
Measured AC/membrane thickness, in.	2.45"
Actual rebar depth measured from AC surface, in. (b)	4.5"
Average correction for every inch depth measured by pachometer over AC, in. $(\frac{b-a}{a})$	0.73 "/"

Actual conc. cover = 2.05

Ave. correction for core # 6, $\frac{b-a}{a} = \frac{3.85" - 2.6"}{2.6"} =$ 0.48 "/"

Ave. correction for core # 7, $\frac{b-a}{a} = \frac{4.1-2.7"}{2.7"} =$ 0.52 "/"

Ave. correction for core # 8, $\frac{b-a}{a} = \frac{3.80" - 2.6"}{2.6"} =$ 0.46 "/"

TOTAL Ave. → 0.55 "/"

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90 /140 S

Weather Condition: Partly cloudy, 60's °F

Core No.: 1

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 10'

Relevant longitudinal grid no.: NO. 7 + 2'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√L		√H
Fabric			
Rubber-Asphalt	√M		
Concrete			

$\bar{C}L$, lb/c.y. Pre-	Post-	Depth
7.81	4.31	1½"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: ____ Sound X Delaminated

General Comments:

M bond between membrane and concrete in this case indicates that membrane was peeled off by hand.

Half-cell reading, v		-.177
Pachometer conducted over AC	Reading	27
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	4.03"
Measured AC/membrane thickness, in. (b)		1.4"
Concrete cover thickness, in. (a-b)		2.63"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/140 S

Weather Condition: Partly cloudy, 60s °F

Core No.: 2

Defective as sounded by chain over AC: ____ Yes __X__ No

Core Location

Distance from curb, ft. 5.5'

Relevant longitudinal grid no.: No. 9 + 2'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+	$\bar{CL}$, lb/c.y. Pre-	Post-	Depth
AC				0.40	0.61	1½"-2"
Fabric	√L	√H				
Rubber-Asphalt	√M					
Concrete						

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: __X__ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: __X__ Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.133
Pachometer conducted over AC	Reading	23
	Converted rebar depth, in.	2.8"
	Adjusted rebar depth, in. (a)	4.34
Measured AC/membrane thickness, in. (b)		2.45"
Concrete cover thickness, in. (a-b)		1.89"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/140 S

Weather Condition: Partly cloudy, 60's °F

Core No.: 3

Defective as sounded by chain over AC: ____ Yes _X_ No

Core Location

Distance from curb, ft. 10.5'

Relevant longitudinal grid no.: No. 16

Layer	Bond[c]	Moisture Presence+	Dyed Moisture Presence+	$\bar{C}L$, lb/c.y. Pre-	Post-	Depth
AC	√L	√M				
Fabric					0.25	0 - 1/2"
Rubber-Asphalt	√H				0.26	1/2" - 1"
Concrete					0.20	1" - 1 1/2"

[c] Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: _X_ Sound _x_ Delaminated Questionable ?

General Comments:

Concrete's appearance suggests patch material.

Half-cell reading, v		-.150
Pachometer conducted over AC	Reading	34
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.72"
Measured AC/membrane thickness, in. (b)		1.25"
Concrete cover thickness, in. (a-b)		2.47"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/140S

Weather Condition: Partly cloudy, 60°s F

Core No.: 4

Defective as sounded by chain over AC: ____ Yes _X_ No

Core Location

Distance from curb, ft. 2'

Relevant longitudinal grid no.: N0.17-3'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√H	√M	
Fabric			
Rubber-Asphalt	√H		
Concrete			

$\bar{CL}$, lb/c.y. Pre-	Post-	Depth
1.88	3.34	1½"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: _X_ Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.169
Pachometer conducted over AC	Reading	34
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.72"
Measured AC/membrane thickness, in. (b)		2.1"
Concrete cover thickness, in. (a-b)		1.62"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/140S

Weather Condition: Partly cloudy, 60°F

Core No.: 4-1

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 6'

Relevant longitudinal grid no.: NO.18-1'

Layer	Bond[c]	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	√L		
Rubber-Asphalt	√L	√L	
Concrete			

Moisture, wt%

Part-	Depth
3.7	1/4"-1 1/2"

[c] Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: ____ Sound X Delaminated

General Comments:

AC core sample fractured.
concrete's surface was spalled while sampling for moisture content by drilling through.

Half-cell reading, v		-.315
Pachometer conducted over AC	Reading	30
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	4.03"
Measured AC/membrane thickness, in. (b)		2.3"
Concrete cover thickness, in. (a-b)		1.73"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/1405

Weather Condition: Partly cloudy, 60°F

Core No.: 5

Defective as sounded by chain over AC: ___ Yes _X_ No

Core Location

Distance from curb, ft. 10.5'

Relevant longitudinal grid no.: No.19-5'

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	✓L	✓M	
Fabric			
Rubber-Asphalt	✓H		
Concrete			

CL, lb/c.y. Pre-	Post-	Depth
	0.19	0-½"
	0.24	½"-1"
	0.35	1"-1½"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: _X_ Sound ___ Delaminated

General Comments:

concrete's appearance suggests patch material.

Half-cell reading, v		-.155
Pachometer conducted over AC	Reading	34
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.72"
Measured AC/membrane thickness, in. (b)		2.35"
Concrete cover thickness, in. (a-b)		1.37"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/140S

Weather Condition: Partly cloudy, 60's F

Core No.: 6

Defective as sounded by chain over AC: ___ Yes X No

Core Location

Distance from curb, ft. 7.5'

Relevant longitudinal grid no.: NO.27

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	↑ √L	√M	
Fabric			
Rubber-Asphalt	√L		
Concrete			

Cl, lb/c.y. Pre-	Post-	Depth
9.05	3.50	1½"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: X Sound ___ Delaminated

General Comments:

Half-cell reading, v		-.145
Pachometer conducted over AC	Reading	28
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	4.03"
Measured AC/membrane thickness, in. (b)		2.35"
Concrete cover thickness, in. (a-b)		1.68"

Drawing and comments on distress in concrete if cored:

Rebar hit @ 1.5" from conc. surface while sampling for chloride.

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/1405

Weather Condition: Partly cloudy, 60°F

Core No.: 7

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 10′

Relevant longitudinal grid no.: NO 28 + 1′

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√L	√M	
Fabric			
Rubber-Asphalt	√M		
Concrete			

CL, lb/c.y. Pre-	Post-	Depth
7.07	6.86	1½″-2″

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound X Delaminated Questionable?

General Comments:

Half-cell reading, v		-.177
Pachometer conducted over AC	Reading	26
	Converted rebar depth, in.	2.7″
	Adjusted rebar depth, in. (a)	4.12″
Measured AC/membrane thickness, in. (b)		2-4″
Concrete cover thickness, in. (a-b)		1.79″

Drawing and comments on distress in concrete if cored:

Rebar hit @ 1.7″ from concrete surface while sampling for chloride.

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/140 S

Weather Condition: Partly cloudy, 60°F

Core No.: 7-1

Defective as sounded by chain over AC: X Yes ___ No

Core Location

Distance from curb, ft. 8'

Relevant longitudinal grid no.: No. 31-3'

	Bond*	Moisture Presence+	Dyed Moisture Presence+
AC	√L	√M	
Fabric			
Rubber-Asphalt	√L	√L	
Concrete			

* Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: ___ Sound X Delaminated

General Comments:

Half-cell reading, v		-.454
Pachometer conducted over AC	Reading	36
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.72"
Measured AC/membrane thickness, in. (b)		2.2"
Concrete cover thickness, in. (a-b)		1.52"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/140S

Weather Condition: Partly cloudy, 60's F

Core No.: 8

Defective as sounded by chain over AC: X Yes ___ No

Core Location

Distance from curb, ft. 11.5'

Relevant longitudinal grid no.: ND.32-4.5'

	Bond[c]	Moisture Presence+	Dyed Moisture Presence+
AC	√L	√M	
Fabric			
Rubber-Asphalt	√L	√M	
Concrete			

[c] Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: ___ Sound X Delaminated

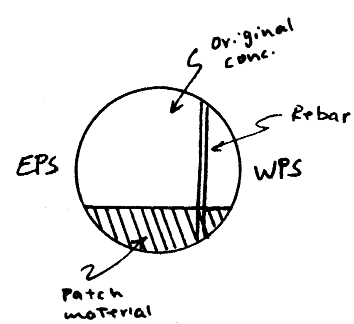
General Comments:

Corete in core location Partially Patch material and Partially original.

Half-cell reading, v		-.429
Pachometer conducted over AC	Reading	30
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	4.03"
Measured AC/membrane thickness, in. (b)		2.1"
Concrete cover thickness, in. (a-b)		1.93"

Drawing and comments on distress in concrete if cored:

Concrete cored:
Concrete was delaminated and was easily freed by drilling and broke in pieces. The patch material was feather edged in this location. After removing the remainder of the concrete by chisel (mainly original concrete in that depth), transverse rebar was exposed having rust all over.
Rebar actually @ 3.8" from AC surface, actual conc. cover thickness =3.8"-2.1"=1.7".



Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/140S

Weather Condition: Partly cloudy, 60°s F

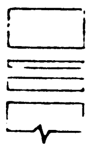
Core No.: 9

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 8.5'

Relevant longitudinal grid no.: No. 37



Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√L	√H	
Fabric			
Rubber-Asphalt	√L		
Concrete			

Moisture, wt%	
Post-	Depth
1.8	1/4"-1 1/2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

Longitudinal crack on AC surface wa full depth crack in AC core sample. Concre sample for moisture was taken, however the core location was exposed about 2 hrs. before sampling.

Half-cell reading, v		-.152
Pachometer conducted over AC	Reading	31
	Converted rebar depth, in.	2.5"
	Adjusted rebar depth, in: (a)	3.86"
Measured AC/membrane thickness, in. (b)		2.05"
Concrete cover thickness, in. (a-b)		1.83"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 9-30-85

Bridge No.: 90/140S

Weather Condition: Partly cloudy, 60°F

Core No.: 10

Defective as sounded by chain over AC: ___ Yes X No

Core Location

Distance from curb, ft. 8.5'

Relevant longitudinal grid no.: No. 39

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√L		
Fabric			
Rubber-Asphalt			
Concrete			

CL, lb/c.y.

Pre-	Post-	Depth
0.79	2.03	1½"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: X Sound ___ Delaminated

General Comments:

Longitudinal crack on AC surface was full depth crack in AC core sample.

Half-cell reading, v		-.154
Pachometer conducted over AC	Reading	38
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.72"
Measured AC/membrane thickness, in. (b)		2.0"
Concrete cover thickness, in. (a-b)		1.72"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/1405

Weather Condition: Partly cloudy, 60°F

Core No.: 10-1

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 11'

Relevant longitudinal grid no.: No.41-5'

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric			
Rubber-Asphalt			
Concrete	√L		

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

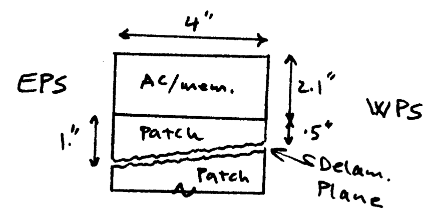
+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: ____ Sound ____ Scaled ____ Spalled (see below)

Result of Sounding Concrete Surface: ____ Sound X Delaminated

General Comments:

Core was drilled beyond membrane into concrete. This freed the delaminated concrete and it came out integrally with AC and membrane. The delaminated concrete is patch material brownish in color (dark) and with finer aggregate. More patch material could be seen under the delamination in the core location.



Half-cell reading, v		-.190
Pachometer conducted over AC	Reading	36
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.72"
Measured AC/membrane thickness, in. (b)		2.1"
Concrete cover thickness, in. (a-b)		1.62"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/140S

Weather Condition: Partly cloudy, 60°F

Core No.: 11

Defective as sounded by chain over AC: ___ Yes X No

Core Location

Distance from curb, ft. 11'

Relevant longitudinal grid no.: NO.45 -4'

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√L	√M	
Fabric			
Rubber-Asphalt	√L		
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: ___ Sound X Delaminated

General Comments:

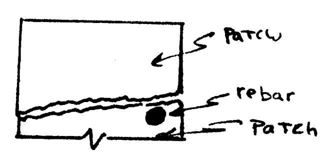
Core location 1.5 feet away from an area designated as defective by chain dragging AC. Concrete's appearance suggests patch material.

Half-cell reading, v		-.184
Pachometer conducted over AC	Reading	29
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	4.03
Measured AC/membrane thickness, in. (b)		2.45"
Concrete cover thickness, in. (a-b)		1.58"

Drawing and comments on distress in concrete if cored:

Concrete cored:

After coring, concrete was not freed. Chisel and hammer had to be used to separate the core sample horizontally, indicating no delaminations. The nature of concrete is patch material. More patch material was left underneath which was removed by chisel exposing the rebar. Sound of delam. on conc. surface might have belonged to the adjacent delam. conc. Rebar actually @ 3.70" from AC surface, actual con. cover thickness = 3.70" - 2.45" = 1.25" | Some very small rust on rebar could be seen



Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-30-85

Bridge No.: 90/140S

Weather Condition: Partly cloudy, 60°sF

Core No.: 12

Defective as sounded by chain over AC: X Yes ___ No

Core Location

Distance from curb, ft. 7'

Relevant longitudinal grid no.: NO. 46+1.5'

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√H		
Fabric			
Rubber-Asphalt	√L	√M	
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: x Sound x Delaminated Questionable?

General Comments:

AC surface pitted with 2" diameter in core location. Completely stripped aggregate in the bottom of AC core sample. The stripped agg. in the bottom of core location acted like a drain and filled the core location with dyed water. This layer was probably the cause of hollow sound.

Half-cell reading, v		-.217
Pachometer conducted over AC	Reading	29
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	4.03
Measured AC/membrane thickness, in. (b)		2.05"
Concrete cover thickness, in. (a-b)		1.98"

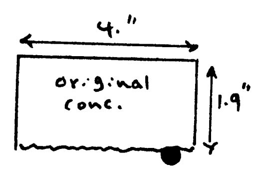
Drawing and comments on distress in concrete if cored:

Concrete Cored:

Concrete was not freed by coring the perimeter and chisel and hammer were used for horizontal separation. Rebar was exposed and no rust could be visually detected.

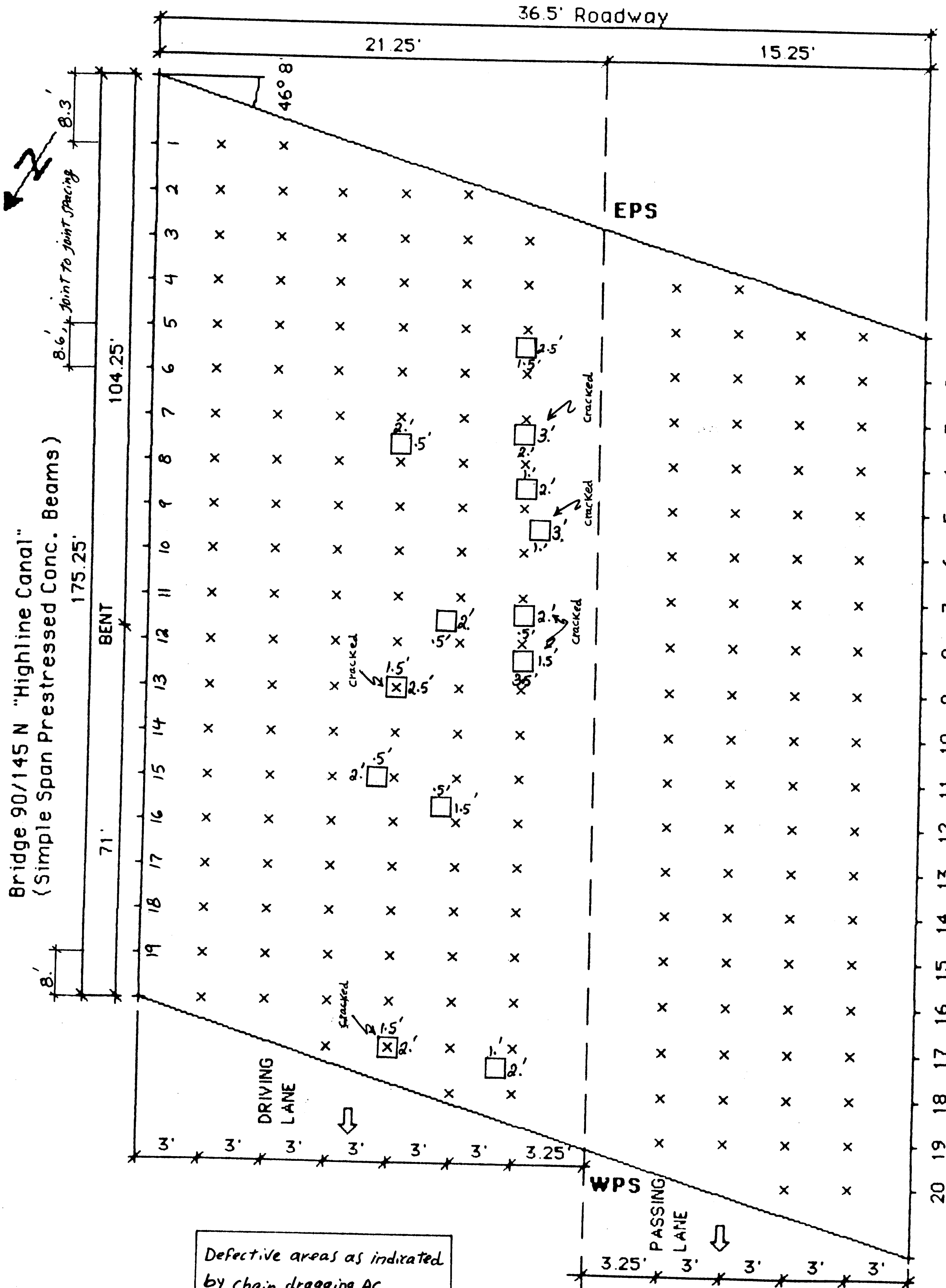
Rebar depth from conc. surface was measured 1.9".

EPS

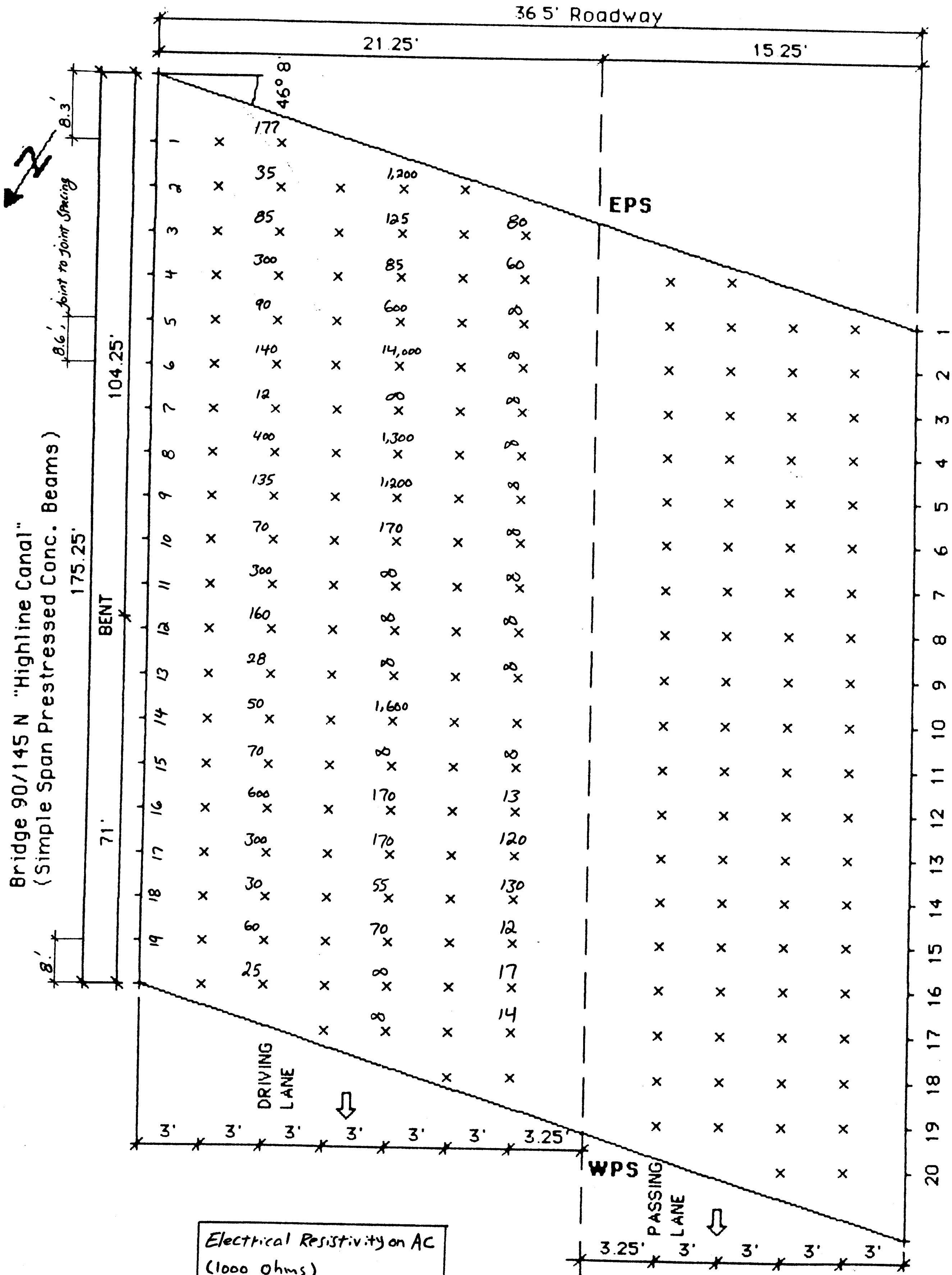


WPS

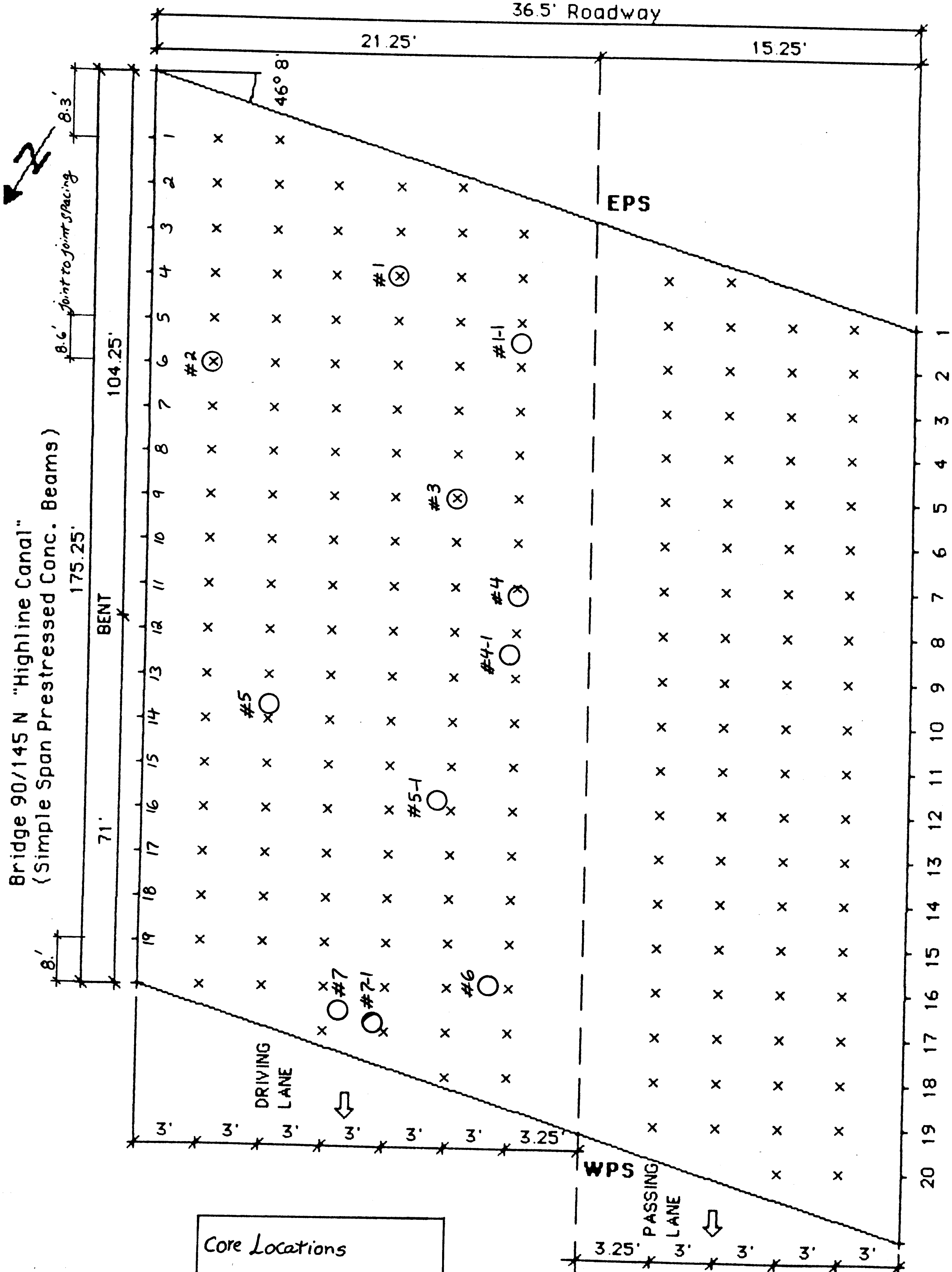
COLLECTED DATA ON BRIDGE 90/145 N



Defective areas as indicated by chain dragging AC 5-21-85



Electrical Resistivity on AC
(1,000 ohms)
5-26-85



Core Locations

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145 N

Weather Condition: Partly Sunny, 70°F

Ground No.: 1

Ground Location

Distance from curb, ft: 6'

Relevant longitudinal grid no.: No.5 +6.5'

Pachometer reading conducted over AC	25
Converted pachometer depth conducted over AC, in. (a)	2.7"
Measured AC/membrane thickness, in.	1.9"
Actual rebar depth measured from AC surface, in. (b)	4.25"
Average correction for every inch depth measured by pachometer over AC, in. $(\frac{b-a}{a})$	0.57 "/"

Actual conc. cover = 2.35"

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145N

Weather Condition: Partly Sunny, 70°sF

Ground No.: 2

Ground Location

Distance from curb, ft: 6'

Relevant longitudinal grid no.: No.16 +3.5'

Rebar Splice in core location, Pachometer read adjacent to the core.

Pachometer reading conducted over AC	25
Converted pachometer depth conducted over AC, in. (a)	2.7"
Measured AC/membrane thickness, in.	2.15"
Actual rebar depth measured from AC surface, in. (b)	4.65"
Average correction for every inch depth measured by pachometer over AC, in. $(\frac{b-a}{a})$	0.72 "/"

Actual conc cover = 2.5

Average correction for grounds No. 1 and 2 (0.57+0.72)/2 0.65 "/"

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145N

Weather Condition: Partly Sunny, 70's F

Core No.: 1

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 12'

Relevant longitudinal grid no.: No.4 -1'

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric			
Rubber-Asphalt	√H		
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

One piece of aggregate from conc. surface came out with the AC core sample.

Half-cell reading, v		-.212
Pachometer conducted over AC	Reading	30
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	4.3"
Measured AC/membrane thickness, in. (b)		2"
Concrete cover thickness, in. (a-b)		2.3"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145 N

Weather Condition: Partly Sunny, 70s °F

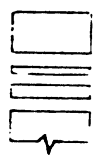
Core No.: 1-1

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 17.5'

Relevant longitudinal grid no.: N 0.5 + 2.5'



Bond°	Moisture Presence+	Dyed Moisture Presence+
↑ √ L (AC/Fabric); √ H (Rubber-Asphalt/Concrete)	√ L →	

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

H bond in this case indicates that membrane was Peeled off by chisel and hand.

→ indicates slightly toward the adjacent category.

Half-cell reading, v		-.278
Pachometer conducted over AC	Reading	36
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	4."
Measured AC/membrane thickness, in. (b)		1.85"
Concrete cover thickness, in. (a-b)		2.15"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145 N

Weather Condition: Partly sunny, 70°s F

Core No.: 2

Defective as sounded by chain over AC: ____ Yes _x_ No

Core Location

Distance from curb, ft. 3'

Relevant longitudinal grid no.: No. 6

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	↑		
Fabric	√L	√L →	
Rubber-Asphalt	√H		
Concrete			

Moisture, wt % Post-	Depth
2.3	1/4"-1 1/2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _x_ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: _x_ Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.109
Pachometer conducted over AC	Reading	29
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	4.3"
Measured AC/membrane thickness, in. (b)		2.35"
Concrete cover thickness, in. (a-b)		1.95"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145 N

Weather Condition: Partly Sunny, 70°sF

Core No.: 3

Defective as sounded by chain over AC: ____ Yes _X_ No

Core Location

Distance from curb, ft. 15'

Relevant longitudinal grid no.: No.9

	Bond°	Moisture Presence+	Dyed Moisture Presence+	CL, lb/c.y. Pre-	Post-	Depth
AC						
Fabric					0.32	0-1/2"
Rubber-Asphalt	√No bond				0.21	1/2"-1"
Concrete					0.20	1"-1 1/2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: ____ Sound ____ Delaminated Questionable

General Comments:

concrete appearance suggests patch material.

Half-cell reading, v		-.346*
Pachometer conducted over AC	Reading	35
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	4."
Measured AC/membrane thickness, in. (b)		2.3"
Concrete cover thickness, in. (a-b)		1.7"

* -.309 when read directly above the chloride sample hole, probably due to lack of surface contact.

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145 N

Weather Condition: Partly Sunny, 70°s F

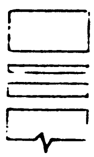
Core No.: 4

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 18'

Relevant longitudinal grid no.: No.11 +1'



	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	↑ √L	√L →	
Rubber-Asphalt	√		
Concrete			

CL, lb/c.y. Pre-	Post-	Depth
	2.59	1->1.5"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: ____ Sound X Delaminated

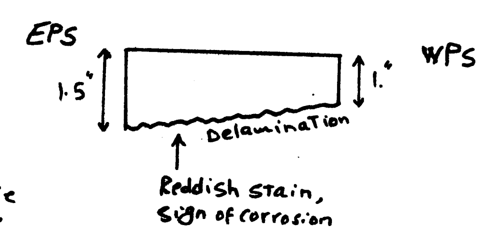
General Comments:

Ac surface cracked in this area.
Concrete appearance suggests patch material.

Half-cell reading, v		-.409
Pachometer conducted over AC	Reading	35
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	4"
Measured AC/membrane thickness, in. (b)		2"
Concrete cover thickness, in. (a-b)		2"

Drawing and comments on distress in concrete if cored:

PCC cored:
The top layer of concrete came out in the coring bore indicating delamination. Concrete is patch material darker in color and mixed with finer aggregate. The material does not seem to be very strong when wet as hit by chisel. A reddish stain, sign of corrosion is visible in the bottom of the delaminated piece in transverse direction. The remaining concrete in core is also patch material. Extension of the plane of delam visible in the circumference of the core.



Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145N

Weather Condition: Partly sunny, 70s °F

Core No.: 4-1

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 18'

Relevant longitudinal grid no.: No. 12 + 3.5'

	Bond*	Moisture Presence+	Dyed Moisture Presence+
AC	←	←	←
Fabric	←	←	←
Rubber-Asphalt	←	←	←
Concrete	← √	←	← √ M

* Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: ____ Sound ____ Scaled X Spalled

Result of Sounding Concrete Surface: ____ Sound ____ Delaminated

General Comments:

AC surface cracked in This area. When chiseling out AC/membrane core sample a layer of surface concrete with a max. thickness of 1/2" came out integrally with the core sample. It is a Patch material and has spalled and disintegrated in the core location. After coring dirt ((disintegrated ground Patch material)) came out of the cracks in AC surface and around The coring location.

Half-cell reading, v		-.389
Pachometer conducted over AC	Reading	35
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	4."
Measured AC/membrane thickness, in. (b)		1.85"
Concrete cover thickness, in. (a-b)		2.15"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145 N

Weather Condition: Partly sunny, 70s °F

Core No.: 5

Defective as sounded by chain over AC: ____ Yes _X_ No

Core Location

Distance from curb, ft. 6'

Relevant longitudinal grid no.: NO.14 -1'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	↑		
Fabric	√L	√H →	
Rubber-Asphalt	√H		
Concrete			

CL, lb/c.y.

Pre-	Post-	Depth
0.20 (1"-4")	1.17	1½"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: _X_ Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.128
Pachometer conducted over AC	Reading	25
	Converted rebar depth, in.	2.7"
	Adjusted rebar depth, in. (a)	4.5"
Measured AC/membrane thickness, in. (b)		2.15"
Concrete cover thickness, in. (a-b)		2.35"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145 N

Weather Condition: Partly sunny, 70's F

Core No.: 5-1

Defective as sounded by chain over AC: X Yes ___ No

Core Location

Distance from curb, ft. 14'

Relevant longitudinal grid no.: No. 16

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	√L	√M →	
Rubber-Asphalt	√M		
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: X Sound ___ Delaminated

General Comments:

Half-cell reading, v		-.353
Pachometer conducted over AC	Reading	35
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	4."
Measured AC/membrane thickness, in. (b)		2.1"
Concrete cover thickness, in. (a-b)		1.9"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145 N

Weather Condition: Partly sunny, 70°F

Core No.: 6

Defective as sounded by chain over AC: ____ Yes _X_ No

Core Location

Distance from curb, ft. 17'

Relevant longitudinal grid no.: NO.20

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√L↓		
Fabric			
Rubber-Asphalt	√L	√M →	
Concrete			

CL, lb/c.y. Pre-	Post-	Depth	Moisture, wt% Post-	Depth
2.23	5.96	1½"-2"	2.6	¼"-1½

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: _X_ Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.375
Pachometer conducted over AC	Reading	28
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	4.3"
Measured AC/membrane thickness, in. (b)		2.1"
Concrete cover thickness, in. (a-b)		2.2"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145 N

Weather Condition: Partly Sunny, 70°F

Core No.: 7 Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 10'

Relevant longitudinal grid no.: NO. 20 + 7'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	√L	√L →	
Rubber-Asphalt	√L		
Concrete			

Cl, lb/c.y.

Pre-	Post-	Depth
4.95	1.96	1½"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: ____ Sound X Delaminated

General Comments:

Half-cell reading, v		-.244
Pachometer conducted over AC	Reading	29
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	4.3"
Measured AC/membrane thickness, in. (b)		2.1"
Concrete cover thickness, in. (a-b)		2.2"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-22-85

Bridge No.: 90/145N

Weather Condition: Partly Sunny, 70°'s F

Core No.: 7-1

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 12'

Relevant longitudinal grid no.: NO. 20 + 9.5'

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric			
Rubber-Asphalt			
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: ____ Sound ____ Scaled ____ Spalled

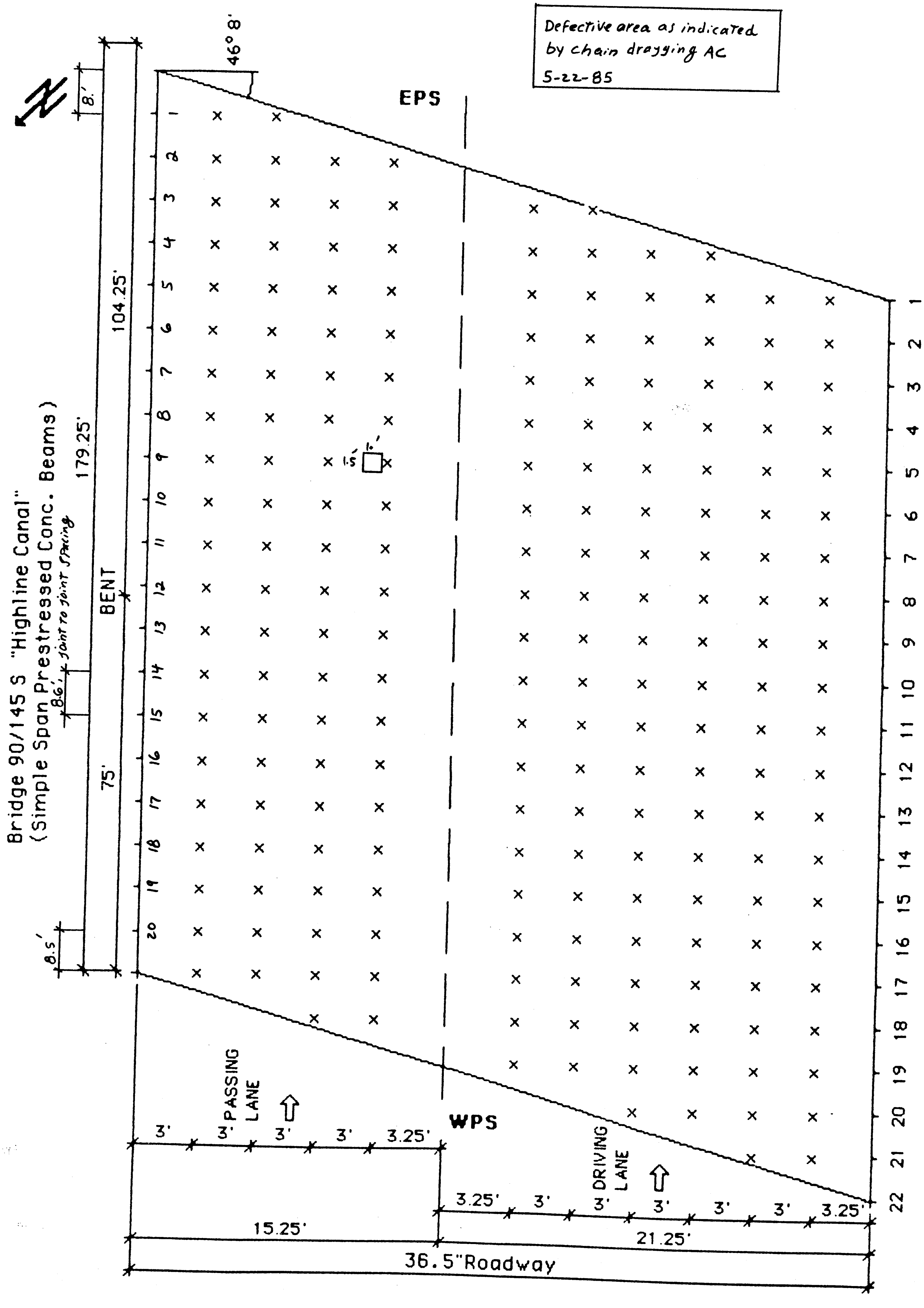
Result of Sounding Concrete Surface: ____ Sound ____ Delaminated

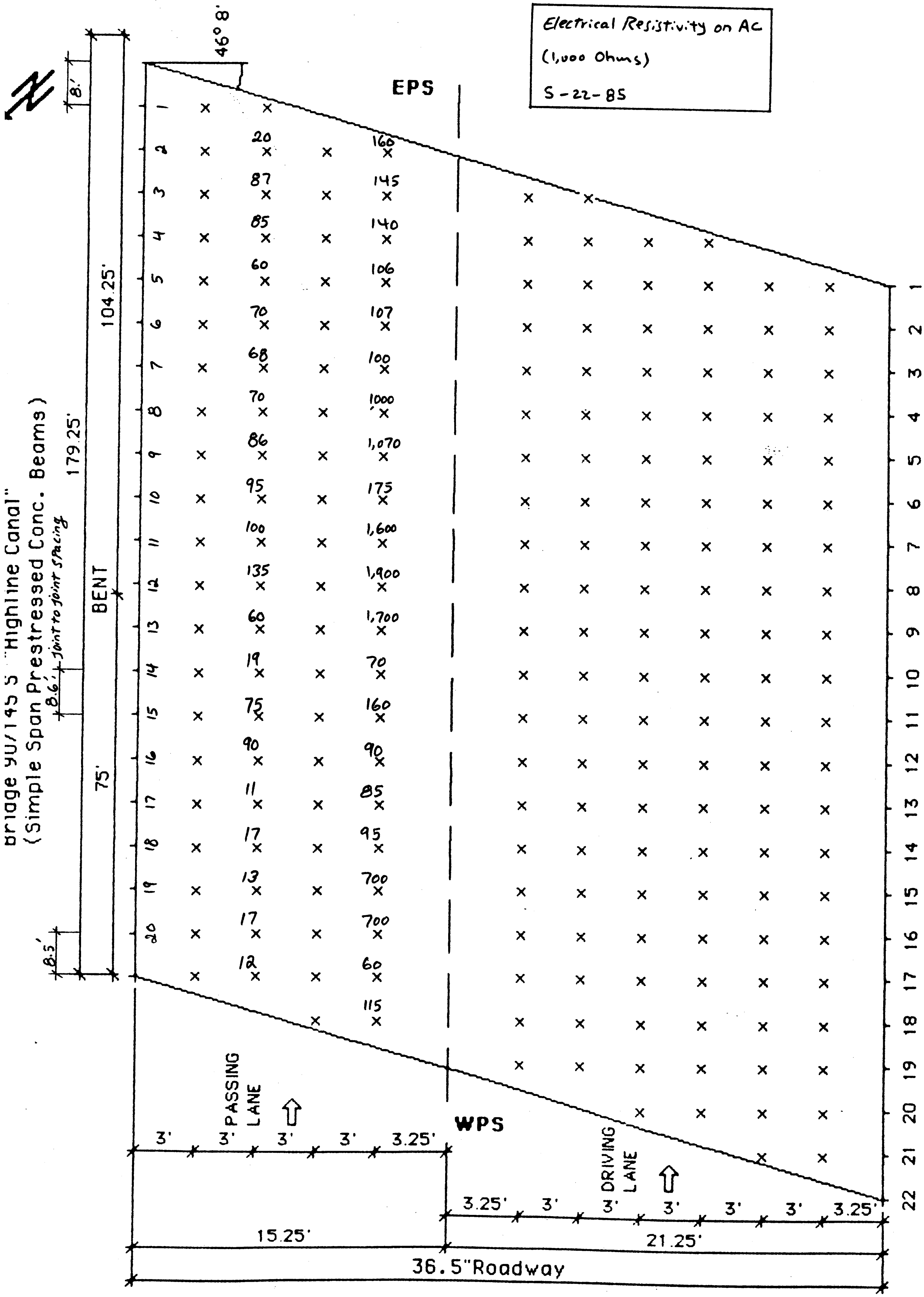
General Comments: Ac surface cracked in This area and depressed. Cored only for PCC through AC. After coring slightly Through PCC (wet coring), The Total sample including AC broke into Pieces and was separated indicating concrete spalling. The nature of concrete is Patch material. The remaining concrete (Patch) was disintegrated and ground in the core location and a cone shape Patch material was left in center.

Half-cell reading, v		-.328
Pachometer conducted over AC	Reading	
	Converted rebar depth, in.	
	Adjusted rebar depth, in. (a)	
Measured AC/membrane thickness, in. (b)		
Concrete cover thickness, in. (a-b)		

Drawing and comments on distress in concrete if cored:

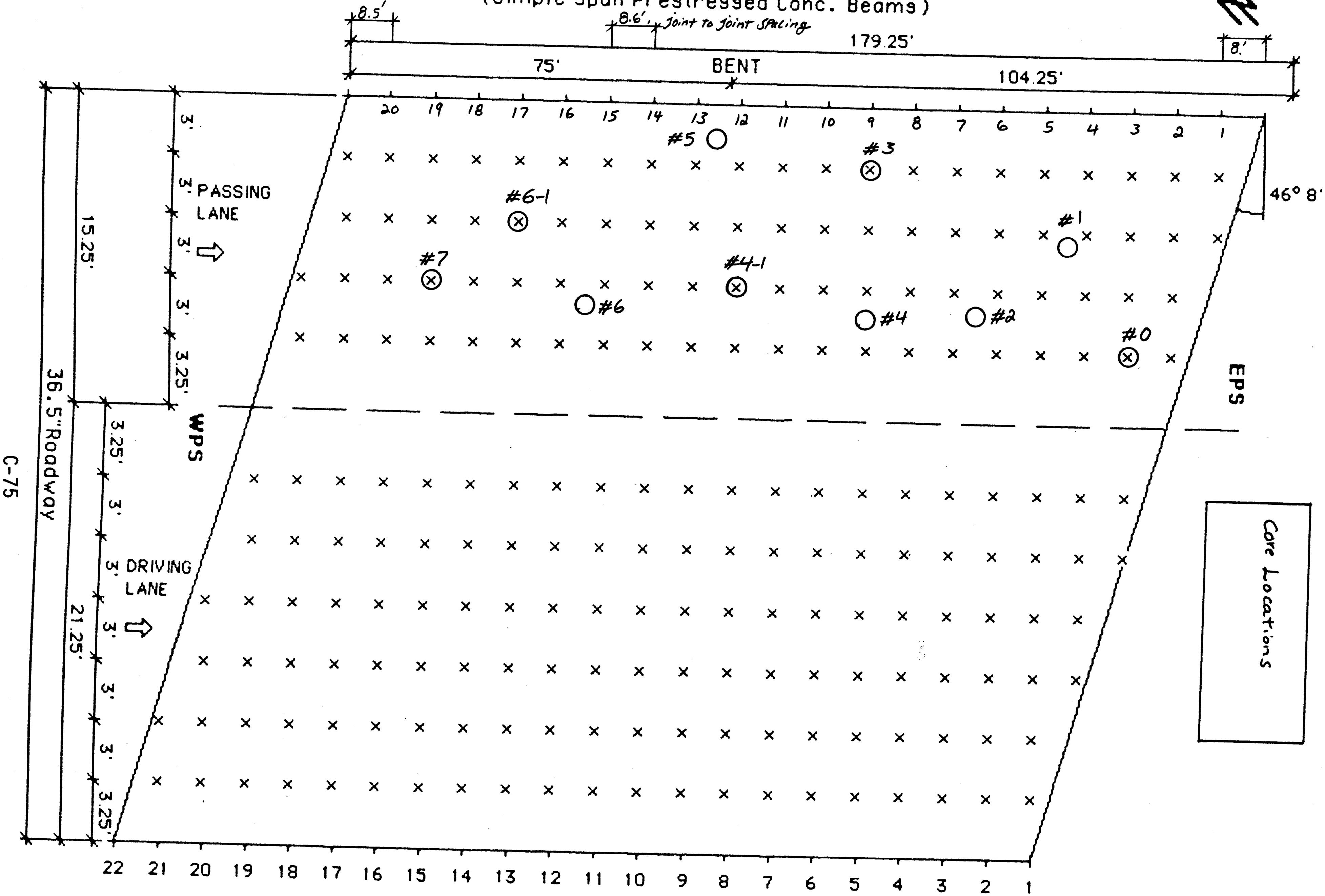
COLLECTED DATA ON BRIDGE 90/145 S


Defective area as indicated by chain dragging AC
5-22-85
Bridge 90/145 S "Highline Canal"
(Simple Span Prestressed Conc. Beams)
46° 8'
8'
104.25'
179.25'
BENT
8.6' Joint to Joint Spacing
75'
8.5'
EPS
WPS
PASSING LANE
DRIVING LANE
3'
3.25'
15.25'
21.25'
36.5"Roadway
1.5'
1'



Electrical Resistivity on AC
(1,000 Ohms)
5-22-85
Bridge 90/145 S "Highline Canal"
(Simple Span Prestressed Conc. Beams)
46°8'
EPS
WPS
104.25'
179.25'
75'
8'
8.6' Joint to joint spacing
8.5'
BENT
20
160
87
145
85
140
60
106
70
107
68
100
70
1000
86
1,070
95
175
100
1,600
135
1,900
60
1,700
19
70
75
160
90
90
11
85
17
95
13
700
17
700
12
60
115
PASSING LANE
DRIVING LANE
3'
3'
3'
3'
3.25'
3.25'
3'
3'
3'
3'
3'
3.25'
15.25'
21.25'
36.5"Roadway

Bridge 90/145 S "Highline Canal"
(Simple Span Prestressed Conc. Beams)



Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-23-85

Bridge No.: 90/145 S

Weather Condition: Partly cloudy, 60's °F

Ground No.: 1

Ground Location

Distance from curb, ft: 3'

Relevant longitudinal grid no.: No. 7+6'

Pachometer reading conducted over AC	27
Converted pachometer depth conducted over AC, in. (a)	2.65"
Measured AC/membrane thickness, in.	2.65"
Actual rebar depth measured from AC surface, in. (b)	4.65"
Average correction for every inch depth measured by pachometer over AC, in. $(\frac{b-a}{a})$	0.75 %

Actual conc. cover = 2."

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-23-85

Bridge No.: 90/145 S

Weather Condition: Partly cloudy, 60's F

Ground No.: 2

Ground Location

Distance from curb, ft: 2.5'

Relevant longitudinal grid no.: No. 17 - 1.5'

Pachometer reading conducted over AC	35
Converted pachometer depth conducted over AC, in. (a)	2.4"
Measured AC/membrane thickness, in.	2.75"
Actual rebar depth measured from AC surface, in. (b)	4.45"
Average correction for every inch depth measured by pachometer over AC, in. $(\frac{b-a}{a})$	0.85 "/"

Actual Conc. cover = 1.7"

Total correction for grounds No. 1 and 2, (0.75 + 0.85) "/"

Average Correction for Core #5, $\frac{b-a}{a}$ = (4.5" - 2.4")/2.4" 0.88 "/"

TOTAL Ave. → 0.83 "/"

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-23-85

Bridge No.: 90/145 S

Weather Condition: Partly cloudy, 60°s F

Core No.: 0

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 12'

Relevant longitudinal grid no.: No. 3

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	↑		
Fabric	√L		
Rubber-Asphalt	√H		
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

H bond in this case indicates that membrane was Peeled of by chisel and hand.

→ Indicates slightly toward the adjacent category

Half-cell reading, v		-.272
Pachometer conducted over AC	Reading	27
	Converted rebar depth, in.	2.65"
	Adjusted rebar depth, in. (a)	4.85"
Measured AC/membrane thickness, in. (b)		2.2"
Concrete cover thickness, in. (a-b)		2.65"

Drawing and comments on distress in concrete if cored: ____

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-23-85

Bridge No.: 90/145 S

Weather Condition: Partly cloudy, 60's °F

Core No.: 1

Defective as sounded by chain over AC: ___ Yes X No

Core Location

Distance from curb, ft. 6.5'

Relevant longitudinal grid no.: No.4 + 3'

	Bond[a]	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric			
Rubber-Asphalt	√M		
Concrete			

CL, lb/c.y. Pre-	Post-	Depth
0.49	1.88	1½"-2"

[a] Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: X Sound ___ Delaminated

General Comments:

A Partial horizontal crack in AC after being chiseled out.

Half-cell reading, v		-.148
Pachometer conducted over AC	Reading	27
	Converted rebar depth, in.	2.65"
	Adjusted rebar depth, in. (a)	4.85"
Measured AC/membrane thickness, in. (b)		2.4"
Concrete cover thickness, in. (a-b)		2.45"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-23-85

Bridge No.: 90/145 S

Weather Condition: Partly cloudy, 60°F

Core No.: 2

Defective as sounded by chain over AC: ____ Yes _x_ No

Core Location

Distance from curb, ft. 10'

Relevant longitudinal grid no.: No.6 + 6'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√L	√L →	
Fabric			
Rubber-Asphalt	√H		
Concrete			

CL, lb/c.y.

Pre-	Post-	Depth
0.84	0.42	1½"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _x_ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: _✓_ Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.120
Pachometer conducted over AC	Reading	27
	Converted rebar depth, in.	2.65"
	Adjusted rebar depth, in. (a)	4.85"
Measured AC/membrane thickness, in. (b)		2.40
Concrete cover thickness, in. (a-b)		2.45"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-23-85

Bridge No.: 90/145 S

Weather Condition: Partly cloudy, 60°F

Core No.: 3

Defective as sounded by chain over AC: ___ Yes X No

Core Location

Distance from curb, ft. 3'

Relevant longitudinal grid no.: No. 9

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	√L → No bond	√H →	
Rubber-Asphalt	√H		
Concrete			

Moisture, wt%

Post-	Depth
3.3	1/4"-1 1/2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: X Sound ___ Delaminated

General Comments:

Half-cell reading, v		-.058
Pachometer conducted over AC	Reading	29
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	4.76"
Measured AC/membrane thickness, in. (b)		2.8"
Concrete cover thickness, in. (a-b)		2.0"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-23-85

Bridge No.: 90/145 S

Weather Condition: Partly cloudy, 60°s

Core No.: 4

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 11'

Relevant longitudinal grid no.: No.9

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric			
Rubber-Asphalt	√L		
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: ____ Sound X Delaminated

General Comments:

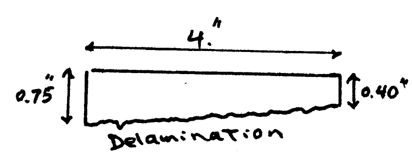
A few concrete surface aggregate came out with AC/mem. core sample.

Half-cell reading, v		-.305
Pachometer conducted over AC	Reading	27
	Converted rebar depth, in.	2.65"
	Adjusted rebar depth, in. (a)	4.85"
Measured AC/membrane thickness, in. (b)		2.25"
Concrete cover thickness, in. (a-b)		2.60"

Drawing and comments on distress in concrete if cored:

Cored for PCC.

The top layer of concrete was delaminated and broke in pieces and was separated with no effort (delaminated part came out in the coring bore). The nature of concrete is original.



Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-23-85

Bridge No.: 90/145 S

Weather Condition: Partly cloudy, 60°s F

Core No.: 4-1

Defective as sounded by chain over AC: ____ Yes _X_ No

Core Location

Distance from curb, ft. 9'

Relevant longitudinal grid no.: No. 12

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	← √L	← √L	←
Fabric	←	←	←
Rubber-Asphalt	←	←	←
	← √H	←	←
Concrete	←	←	←

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: _X_ Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.256
Pachometer conducted over AC	Reading	31
	Converted rebar depth, in.	2.5"
	Adjusted rebar depth, in. (a)	4.58"
Measured AC/membrane thickness, in. (b)		2.4"
Concrete cover thickness, in. (a-b)		2.18"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-23-85

Bridge No.: 90/145 S

Weather Condition: Partly cloudy, 60°F

Core No.: 5

Defective as sounded by chain over AC: ____ Yes __X__ No

Core Location

Distance from curb, ft. 2'

Relevant longitudinal grid no.: No. 13 - 2'

	Bond*	Moisture Presence+	Dyed Moisture Presence+
AC	← √L → no bond	← √L	←
Fabric	←	←	←
Rubber-Asphalt	← √H	←	←
Concrete	←	←	←

CL, lb/c.y.

Pre-	Post-	Depth
0.49	0.59	1½"-2"

* Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: __X__ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: __X__ Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.083
Pachometer conducted over AC	Reading	35
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	4.39"
Measured AC/membrane thickness, in. (b)		2.8"
Concrete cover thickness, in. (a-b)		1.59"

Drawing and comments on distress in concrete if cored:

Rebar hit at 4.5" from AC surface while sampling for chloride, actual conc. cover thickness = 4.5" - 2.8" = 1.7"

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-23-85

Bridge No.: 90/145 S

Weather Condition: Partly cloudy, 60's F

Core No.: 6

Defective as sounded by chain over AC: ____ Yes __x__ No

Core Location

Distance from curb, ft. 9'

Relevant longitudinal grid no.: No.15 + 3'

Layer	Bond[a]	Moisture Presence+	Dyed Moisture Presence+	CL, lb/c.y. Pre-	Post-	Depth
AC	←√L	←√M→	←	1.58	2.87	3/4" - 1 1/4"
Fabric	←	←	←	0.54	1.55	1 1/4" - 2 1/4"
Rubber-Asphalt	←√H	←	←	0.25	0.12	2 1/4" - 2 3/4"
Concrete	←	←	←			

[a] Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: __X__ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: __X__ Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.187
Pachometer conducted over AC	Reading	25
	Converted rebar depth, in.	2.7"
	Adjusted rebar depth, in. (a)	4.94"
Measured AC/membrane thickness, in. (b)		2.25"
Concrete cover thickness, in. (a-b)		2.69"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-23-85

Bridge No.: 90/145 S

Weather Condition: Partly cloudy, 60°s F

Core No.: 6-1

Defective as sounded by chain over AC: ____ Yes __X__ No

Core Location

Distance from curb, ft. 6'

Relevant longitudinal grid no.: No. 16

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	√L	√L	
Fabric			
Rubber-Asphalt	√L		
Concrete			

Moisture, wt%	
Post-	Depth
3.8	1/4"-1 1/2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: __X__ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: __X__ Sound ____ Delaminated

General Comments:

Concrete's surface appearance suggests patch material.

Half-cell reading, v		-.172
Pachometer conducted over AC	Reading	29
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	4.76"
Measured AC/membrane thickness, in. (b)		2.35"
Concrete cover thickness, in. (a-b)		2.41"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-23-85

Bridge No.: 90/145 S

Weather Condition: Partly cloudy, 60°s F

Core No.: 7

Defective as sounded by chain over AC: ____ Yes _x_ No

<u>Core Location</u>

Distance from curb, ft. 9'

Relevant longitudinal grid no.: NO.19

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	✓L	✓L	
Fabric			
Rubber-Asphalt	✓H		
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _x_ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: _x_ Sound ____ Delaminated

<u>General Comments</u>:

Concrete's surface appearance suggests patch material.

Half-cell reading, v		-.202
Pachometer conducted over AC	Reading	34
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	4.39"
Measured AC/membrane thickness, in. (b)		2.15"
Concrete cover thickness, in. (a-b)		2.24"

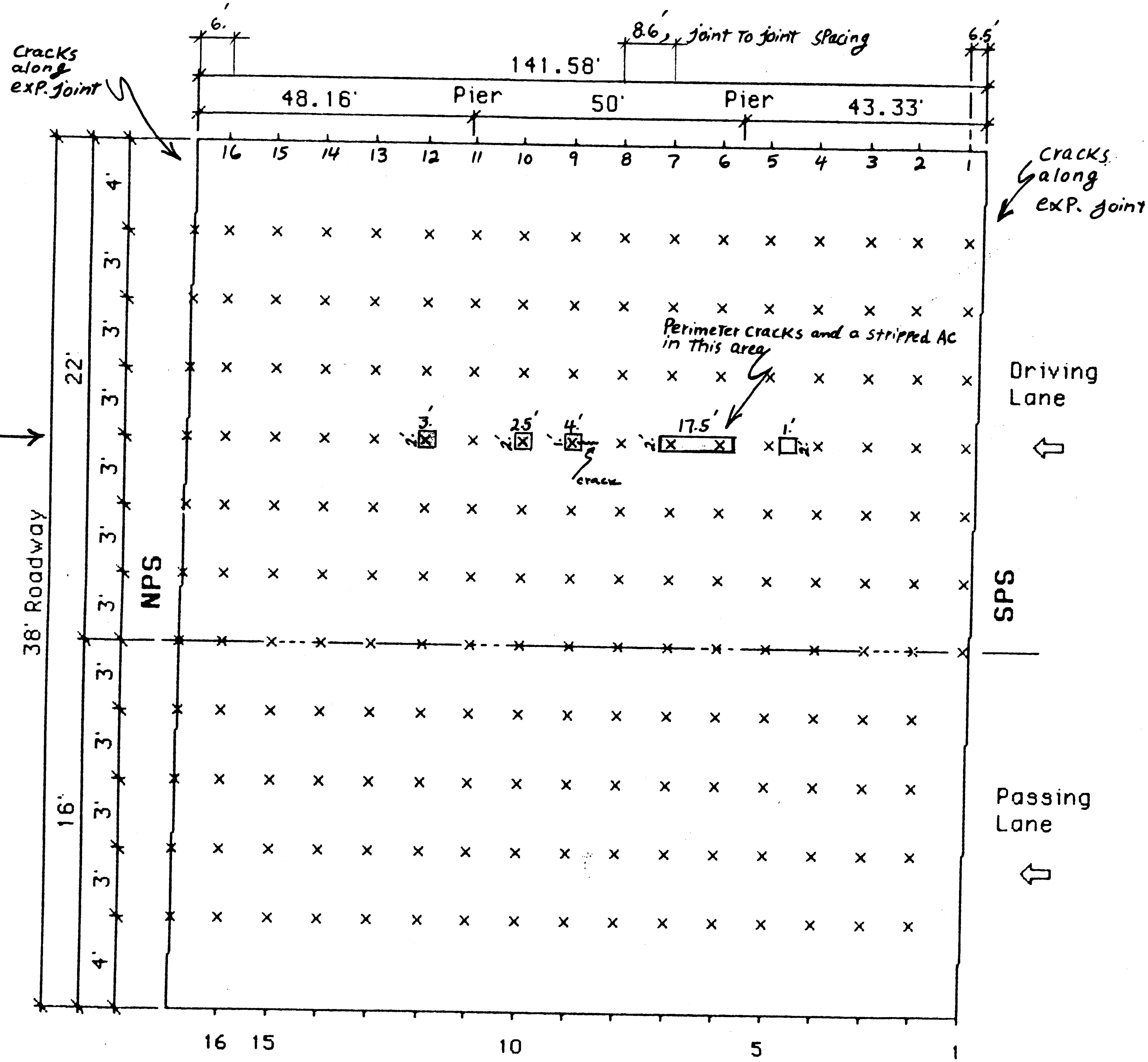
Drawing and comments on distress in concrete if cored: ____

COLLECTED DATA ON BRIDGE 82/20 N

Bridge 82/20 N "Squaw Cr R OC"
(Partially continuous prestressed conc. beams)

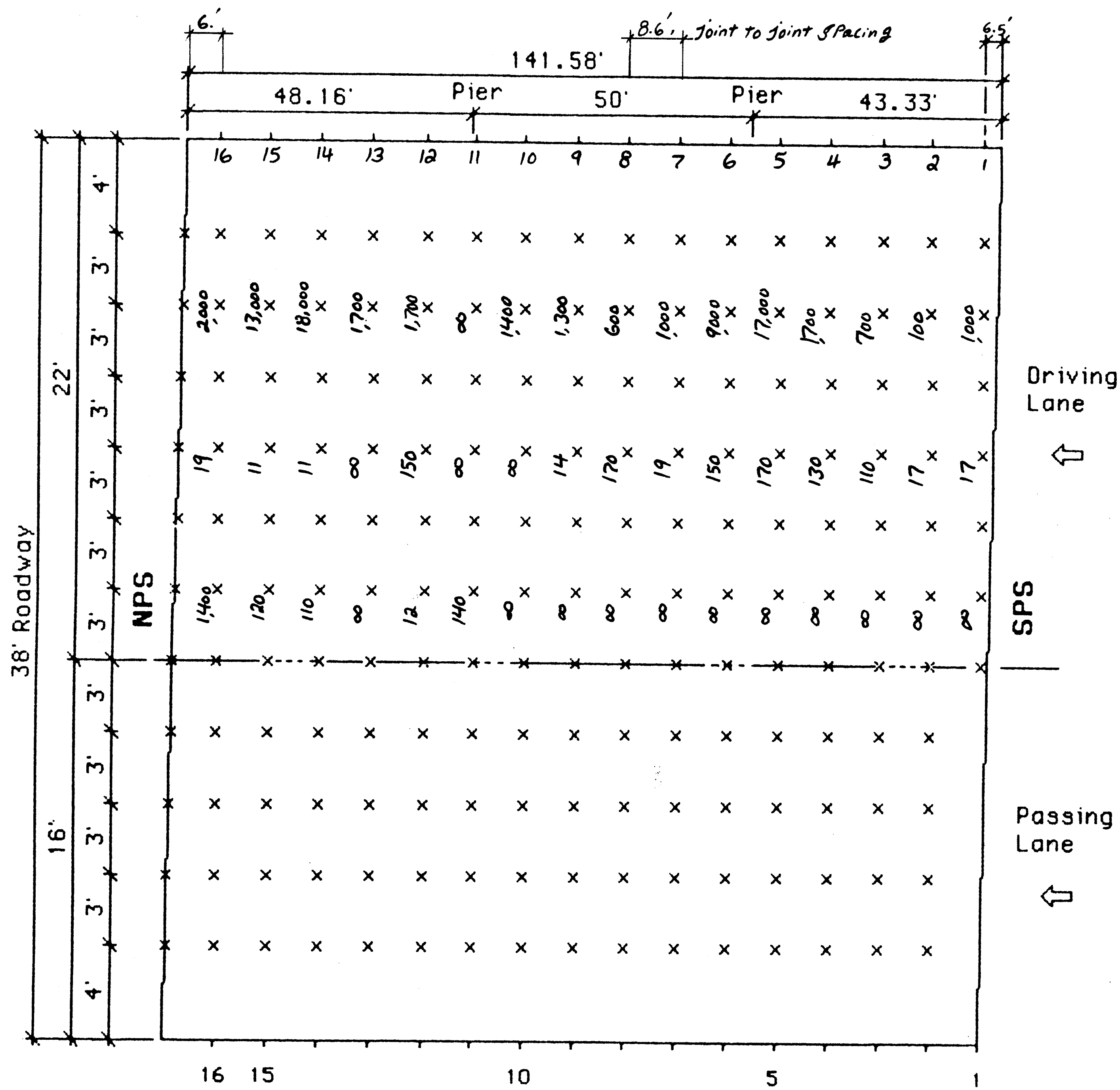
Defective areas as indicated by chain dragging AC 5-20-85

Coincidence of construction joint and wheel path along this line



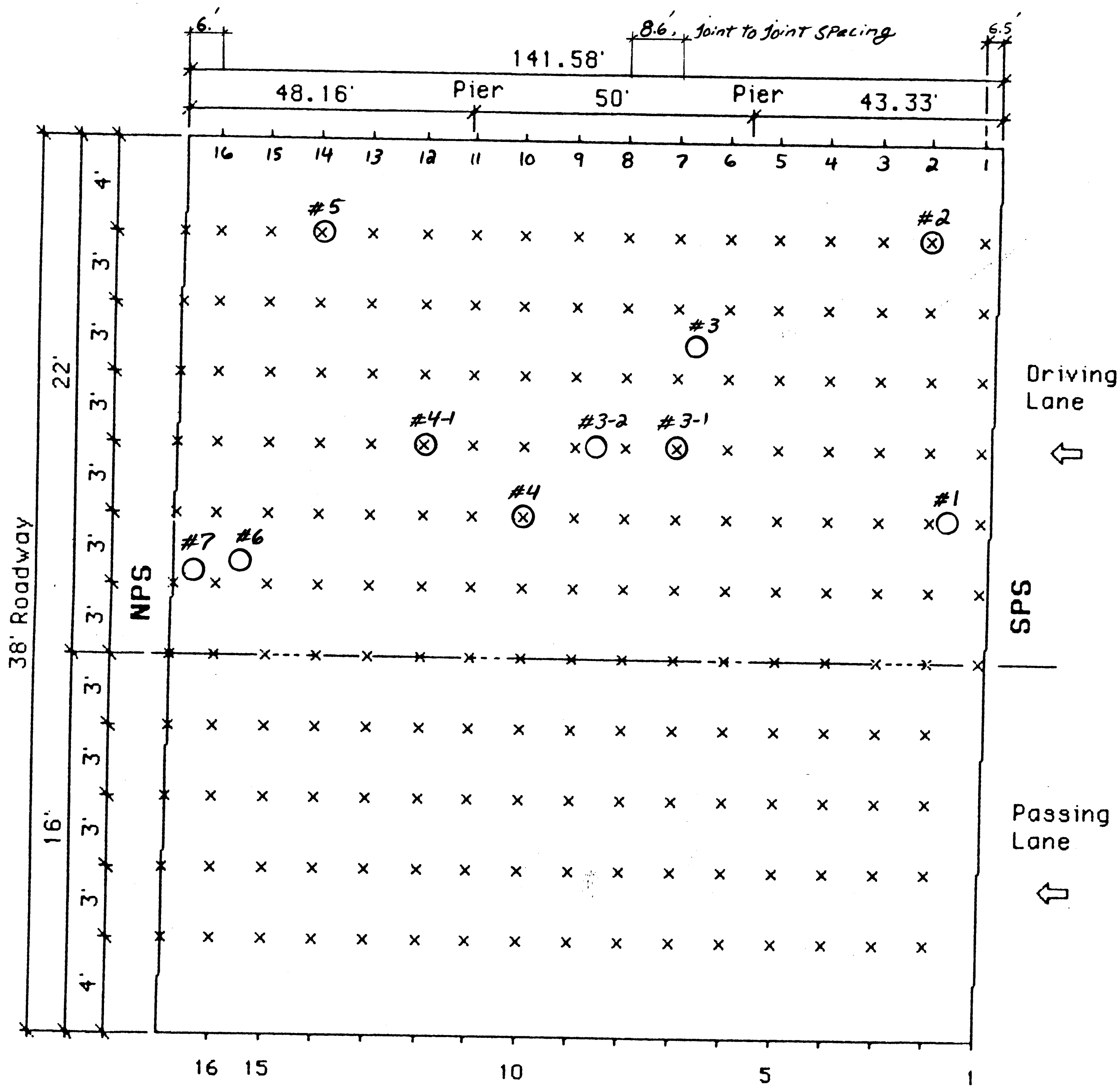
Bridge 82/20 N "Squaw Cr R OC"
(Partially continuous prestressed conc. beams)

Electrical resistivity on AC
(1,000 ohms)
5-20-85



Bridge 82/20 N "Squaw Cr R OC"
(Partially continuous prestressed conc. beams)

Core Locations



Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-20-85

Bridge No.: 82/20 N

Weather Condition: Sunny, 70s° F

Ground No.: 1

Ground Location

Distance from curb, ft: 5'

Relevant longitudinal grid no.: No. 8 + 3'

Pachometer reading conducted over AC	31
Converted pachometer depth conducted over AC, in. (a)	2.6"
Measured AC/membrane thickness, in.	2"
Actual rebar depth measured from AC surface, in. (b)	3.9"
Average correction for every inch depth measured by pachometer over AC, in. $(\frac{b-a}{a})$	0.50 %

Actual conc. cover = 1.9"

Average correction for core #3, $\frac{b-a}{a} = \frac{3.3" - 2.4"}{2.4"}$ = 0.38 %

Average correction for core #4-1, $\frac{b-a}{a} = \frac{3.5" - 2.4"}{2.4"}$ = 0.49 %

TOTAL Ave. → 0.46 %

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5- 20- 85

Bridge No.: 82/20 N

Weather Condition: Sunny, 70s °F

Core No.: 1

Defective as sounded by chain over AC: ___ Yes _x_ No

Core Location

Distance from curb, ft. 16'

Relevant longitudinal grid no.: No. 1 + 4.6'

	Bond°	Moisture Presence+	Dyed Moisture Presence+	Cl, lb/c.y. Pre-	Post-	Depth
AC	← ✓L	←	← ✓L		9.59	0-½"
Fabric	←	←	←		10.99	½"-1"
Rubber-Asphalt	← ✓H	←	←		4.56	1"-1½"
Concrete	←	←	←	4.39	5.31	1½"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: _x_ Sound ___ Delaminated

General Comments:

H bond between membrane and concrete in this case indicates That The membrane was Peeled off by chisel and hand

Half-cell reading, v		-.200
Pachometer conducted over AC	Reading	31
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	3.8"
Measured AC/membrane thickness, in. (b)		2"
Concrete cover thickness, in. (a-b)		1.8"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-20-85

Bridge No.: 82/20 N

Weather Condition: Sunny, 70°F

Core No.: 2

Defective as sounded by chain over AC: ____ Yes _X_ No

<u>Core Location</u>

Distance from curb, ft. 4'

Relevant longitudinal grid no.: NO. 2

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
AC / Fabric	✓ L		✓ M
Fabric			
Rubber-Asphalt			
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: _X_ Sound ____ Delaminated

<u>General Comments</u>:

Half-cell reading, v		-.083
Pachometer conducted over AC	Reading	32
	Converted rebar depth, in.	2.6"
	Adjusted rebar depth, in. (a)	3.8"
Measured AC/membrane thickness, in. (b)		2"
Concrete cover thickness, in. (a-b)		1.8"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-20-85

Bridge No.: 82/20 N

Weather Condition: Sunny, 70°F

Core No.: 3

Defective as sounded by chain over AC: ___ Yes _X_ No

Core Location

Distance from curb, ft. 9'

Relevant longitudinal grid no.: No. 6 + 5'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+	CL, lb/c.y. Pre-	Post-	Depth
AC	←	←	←		10.83	0 - 1/2"
Fabric	←	←	←		5.09	1/2" - 1"
Rubber-Asphalt	← ✓ L	←	←		3.30	1" - 1 1/2"
Concrete	←	←	←	3.54	3.21	1 1/2" - 2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: _X_ Sound ___ Delaminated

General Comments:

Half-cell reading, v		-.195
Pachometer conducted over AC	Reading	37
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.5"
Measured AC/membrane thickness, in. (b)		2."
Concrete cover thickness, in. (a-b)		1.5"

Drawing and comments on distress in concrete if cored:

Rebar hit @ 3.3" while sampling for chloride, actual conc. cover thickness = 3.3" - 2." = 1.3"

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-20-85

Bridge No.: 82/20 N

Weather Condition: Sunny, 70°s F

Core No.: 3-1

Defective as sounded by chain over AC: X Yes ____ No

Core Location

Distance from curb, ft. 13'

Relevant longitudinal grid no.: No. 7

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	✓ No bond		
Rubber-Asphalt	✓ No bond	✓ L	
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

AC surface cracked and depressed.

Aggregate completely stripped in the bottom layer of AC and top of membrane probably due to accumulation of water.

No interface bond.

Half-cell reading, v		-.233
Pachometer conducted over AC	Reading	37
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.5"
Measured AC/membrane thickness, in. (b)		1.9"
Concrete cover thickness, in. (a-b)		1.6"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-21-85

Bridge No.: 82/20 N

Weather Condition: Sunny, 70's °F

Core No.: 3-2

Defective as sounded by chain over AC: X Yes ___ No

Core Location

Distance from curb, ft. 13'

Relevant longitudinal grid no.: No.9 - 1.5'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	✓ no bond		✓ L
Rubber-Asphalt	✓ no bond		✓ L
Concrete			

Moisture, wt%

Post-	Depth
2.4	1/4"-1 1/2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: X Sound ___ Delaminated

General Comments:

Aggregate stripped in the bottom of AC and top of membrane probably due to accumulation of water.

Half-cell reading, v		-.267
Pachometer conducted over AC	Reading	38
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.5"
Measured AC/membrane thickness, in. (b)		1.6"
Concrete cover thickness, in. (a-b)		1.9"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-21-85

Bridge No.: 82/20 N

Weather Condition: Sunny, 70°F

Core No.: 4

Defective as sounded by chain over AC: ____ Yes __X__ No

Core Location

Distance from curb, ft. 16'

Relevant longitudinal grid no.: No. 10

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	√L	√L	
Rubber-Asphalt	√H		
Concrete			

Moisture, wt%

Post-	Depth
2.2	1/4"-1 1/2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: __X__ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: __X__ Sound ____ Delaminated

General Comments:

Half-cell reading, v		-.235
Pachometer conducted over AC	Reading	37
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.5"
Measured AC/membrane thickness, in. (b)		1.95"
Concrete cover thickness, in. (a-b)		1.6"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-21-85

Bridge No.: 82/20 N

Weather Condition: Sunny, 70's °F

Core No.: 4-1

Defective as sounded by chain over AC: X Yes ___ No

Core Location

Distance from curb, ft. 13'

Relevant longitudinal grid no.: No. 12 + 2.5'

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	√ No bond	√ H	
Rubber-Asphalt			
Concrete	√ L		√ L

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

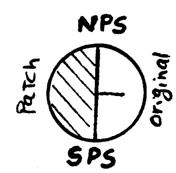
+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: x Sound ___ Delaminated

General Comments:

Longitudinal boundary of Patch concrete visible in core locations on concrete surface. A short Transverse line also visible on concrete surface (crack?).



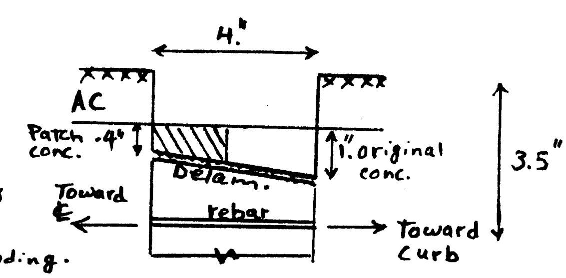
Half-cell reading, v		-.419
Pachometer conducted over AC	Reading	38
	Converted rebar depth, in.	2.4"
	Adjusted rebar depth, in. (a)	3.5"
Measured AC/membrane thickness, in. (b)		1.9"
Concrete cover thickness, in. (a-b)		1.6"

Drawing and comments on distress in concrete if cored:

Pcc cored:

The Top layer of concrete came out in The coring bore indicating delamination. Concrete left in Place was removed by chisel and rebar exposed in core location. Corrosion was not detected visually. Nearby rebar could be corroding. Rebar hit @ 3.5" from AC.

Actual conc. cover Thickness = 3.5" - 1.9" = 1.6"



Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-21-85

Bridge No.: 82/20 N

Weather Condition: Sunny, 70's °F

Core No.: 5

Defective as sounded by chain over AC: ____ Yes _X_ No

Core Location

Distance from curb, ft. 4'

Relevant longitudinal grid no.: No. 14

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	√L		√L
Rubber-Asphalt	√H		
Concrete			

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: _X_ Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: _X_ Sound ____ Delaminated

General Comments:

Half-cell reading, v		-0.107
Pachometer conducted over AC	Reading	33
	Converted rebar depth, in.	2.5"
	Adjusted rebar depth, in. (a)	3.7"
Measured AC/membrane thickness, in. (b)		2.2"
Concrete cover thickness, in. (a-b)		1.5"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-21-85

Bridge No.: 82/20 N

Weather Condition: Sunny, 70°F

Core No.: 6

Defective as sounded by chain over AC: ___ Yes X No

Core Location

Distance from curb, ft. 18'

Relevant longitudinal grid no.: NO.15+4'

Layer	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC	←	←	←
Fabric	←	←	←
Rubber-Asphalt	←	←	←
	← √L	←	← √H
Concrete	←	←	←

CL, lb/c.y.

Pre-	Post-	Depth
	0.29	0-1/2"
	0.29	1/2"-1"
	0.32	1"-1 1/2"
	0.12	1 1/2"-2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

\+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ___ Scaled ___ Spalled

Result of Sounding Concrete Surface: X Sound ___ Delaminated

General Comments:

Concrete surface chipped easily, suggesting patch material

Half-cell reading, v		-.251
Pachometer conducted over AC	Reading	39
	Converted rebar depth, in.	2.3"
	Adjusted rebar depth, in. (a)	3.4"
Measured AC/membrane thickness, in. (b)		1.5"
Concrete cover thickness, in. (a-b)		1.9"

Drawing and comments on distress in concrete if cored:

Project: WSDOT/TRAC Bridge Deck Research, Membrane

Date: 5-21-85

Bridge No.: 82/20 N

Weather Condition: Sunny, 70's F

Core No.: 7

Defective as sounded by chain over AC: ____ Yes X No

Core Location

Distance from curb, ft. 18.5'

Relevant longitudinal grid no.: No.16 + 2.5'

	Bond°	Moisture Presence+	Dyed Moisture Presence+
AC			
Fabric	√ No bond		√ M
Rubber-Asphalt	√ L		√ M
Concrete			

CL, lb/c.y.

Pre-	Post-	Depth
	0.25	0 - 1/2"
	0.36	1/2" - 1"
	0.23	1" - 1 1/2"

° Mark the plane of separation when core is being chiseled out and indicate interface bond as applicable as low, moderate or high (L, M, H).

+ Indicate moisture presence as applicable as low, moderate or high (L, M, H).

Concrete Surface Appearance: X Sound ____ Scaled ____ Spalled

Result of Sounding Concrete Surface: X Sound ____ Delaminated

General Comments:

Concrete surface chipped easily suggesting repair material

Half-cell reading, v		-.281
Pachometer conducted over AC	Reading	42
	Converted rebar depth, in.	2.2"
	Adjusted rebar depth, in. (a)	3.2"
Measured AC/membrane thickness, in. (b)		2"
Concrete cover thickness, in. (a-b)		1.2"

Drawing and comments on distress in concrete if cored: