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Preventing Concrete Deterioration

Effectiveness of Darex Corrosion Inhibitor

WA-RD 104.1

Final Report
January 1987



Washington State Department of Transportation

Planning, Research and Public Transportation Division

in cooperation with the
United States Department of Transportation
Federal Highway Administration

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
TECHNICAL REPORT STANDARD TITLE PAGE

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		15. SUPPLEMENTARY NOTES This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.	
16. ABSTRACT <p>Darex Corrosion Inhibitor (DCI) was specified for use in the Dogfish Bay Bridge on SR 308 in Kitsap County. The bridge is a 90-foot long structure located within a tidal zone. The superstructure is an 18-inch deep prestressed concrete slab. The end piers and two intermediate piers each consist of six 16½-inch prestressed concrete piles. DCI was added to all concrete used in the slab and piles except for four control piles (one in each pier). The supplier, Grace Construction Products, claims that the Calcium Nitrite contained in DCI will, when used as an additive in the recommended dosage, strengthen the passivating film around the reinforcing steel "making it more resistant to chloride penetration," thereby protecting the steel against corrosion. (The process is explained in detail in Appendix A.) However, only half of the recommended amount of DCI was added to the test sections. At this dosage, DCI appears to be no more effective than standard Portland Cement Concrete in preventing corrosion of the reinforcing steel.</p>			
17. KEY WORDS Darex Corrosion Inhibitor, DCI, Calcium Nitrite, chloride, bridge substructure		18. DISTRIBUTION STATEMENT	
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EFFECTIVENESS OF DAREX CORROSION INHIBITOR
IN PREVENTING CONCRETE DETERIORATION

by

Ed Henley
Bridge Technology Development Engineer

Final Report
Experimental Feature WA 81-01

Prepared for
Washington State Transportation Commission
Department of Transportation
and in cooperation with
U.S. Department of Transportation
Federal Highway Administration

January, 1987

DISCLAIMER

The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Washington State Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification or regulation.

TABLE OF CONTENTS

	<u>PAGE</u>
VICINITY MAP	0
SYNOPSIS	1
CONSTRUCTION SUMMARY	2
COST	2
TEST RESULTS	3
CORROSION STANDARDS	4
CONCLUSION	4
REFERENCES	5
APPENDIX A ("Mechanism of Corrosion, How DCI Works")	6
B (Change Order No. 2)	9
C (Change Order No. 3)	14
D (Prestressed Slab Reports)	17
E (Prestressed Pile Reports)	21
F (Bridge Layout)	27

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

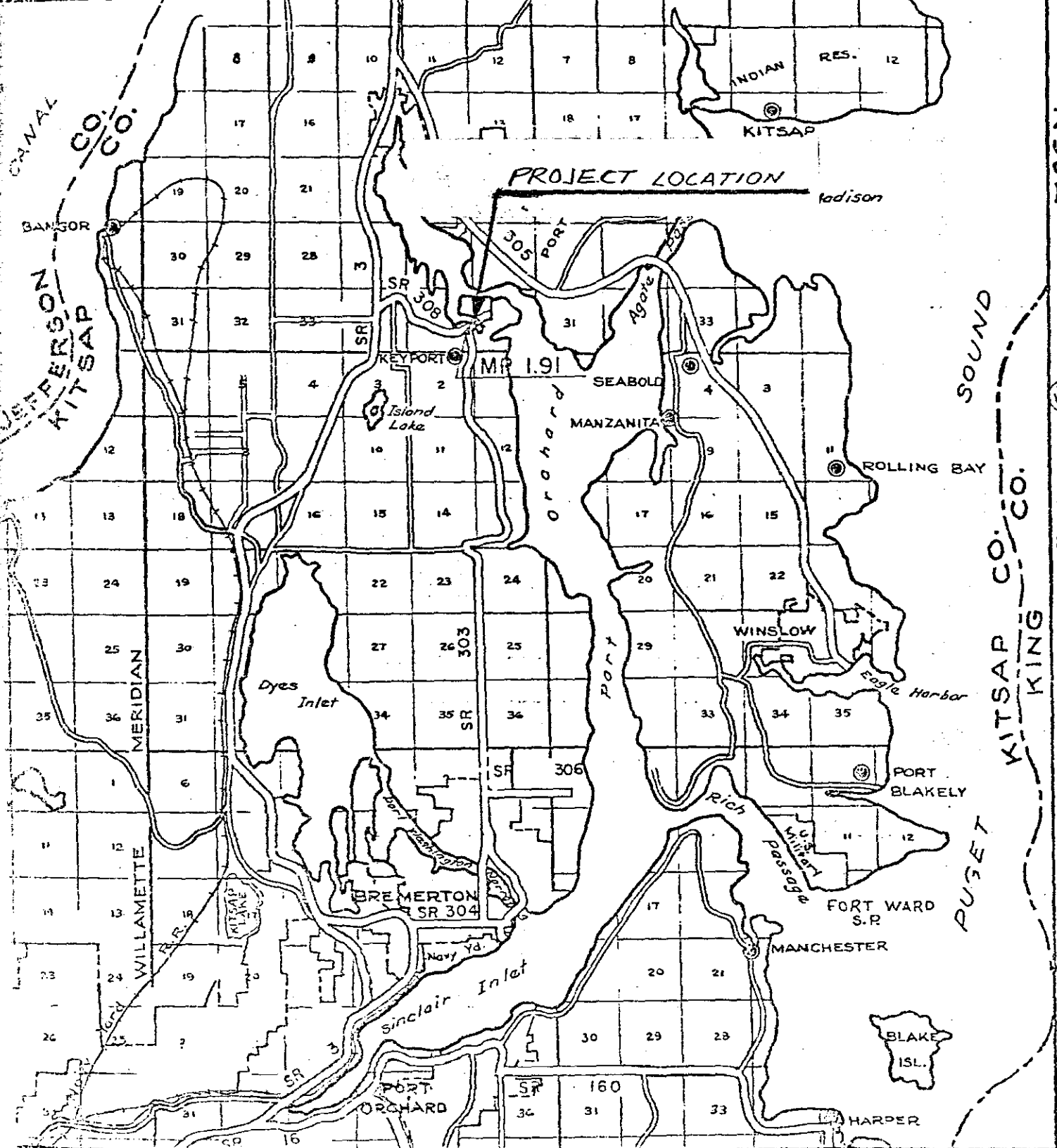
OLYMPIA, WASHINGTON

MAP OF STATE HIGHWAYS

KITSAP COUNTY

REVISED 1961

3rd Improvement Shown in RED



SYNOPSIS

Darex Corrosion Inhibitor (DCI) was specified for use in the Dogfish Bay Bridge on SR 308 in Kitsap County. The bridge is a 90-foot long structure located within a tidal zone. The superstructure is an 18-inch deep prestressed concrete slab. The end piers and two intermediate piers each consist of six 16½-inch prestressed concrete piles. DCI was added to all concrete used in the slab and piles except for four control piles (one in each pier). The supplier, Grace Construction Products, claims that the Calcium Nitrite contained in DCI will, when used as an additive in the recommended dosage, strengthen the passivating film around the reinforcing steel "making it more resistant to chloride penetration," thereby protecting the steel against corrosion. (The process is explained in detail in Appendix A.) However, only half of the recommended amount of DCI was added to the test sections. At this dosage, DCI appears to be no more effective than standard Portland Cement Concrete in preventing corrosion of the reinforcing steel.

CONSTRUCTION SUMMARY

Prior to construction, use of DCI and the installation of a half cell potential monitoring system were incorporated into the contract by change order. The control piles were driven in July 1981. DCI was added to the concrete mix for the remaining precast piles and slabs which were poured in August 1981. Forty-two point five (42.5) fluid ounces of DCI was added per 100 pounds of cement. The rate recommended by Grace and specified in the change order was two percent by weight of cement (85 fl. oz/cwt cement). This fabrication error was not detected during the construction. The prestressed units were in place by December 1981 at which time the bridge was opened to traffic. The project was completed after sealing the deck on April 2, 1982.

COST

The total cost to incorporate DCI on this project and to provide a monitoring system was \$8,596. The cost to add the DCI to the concrete was \$47.66 per cubic yard of concrete, for a total of \$7,625. This total represented 2.8 percent of the total bridge construction costs.

TEST RESULTS

Samples were taken to determine chloride content and half cell potential measurements were made in September 1984. The results are given in the table below. The sample locations are shown in Appendix F.

No.	Sample Location	Chloride Content (lb/CY)(A)			Average Half Cell (V)
		1"-1½"	1½"-2"	2"-2½"	
<u>Control Pile</u>					
1	Pier 2: 1 foot below cap within tidal zone	7.41	4.20	0.78	-0.242
		5.71	2.72	1.57	-0.353
<u>Experimental Piles</u>					
2	Pier 2: 1 foot below cap within tidal zone	5.38	2.97	1.14	-0.224
		8.42	7.27	4.56	-0.448
3	Pier 3: 1 foot below cap within tidal zone	7.08	4.06	1.61	-0.269
		5.48	3.38	1.37	-0.421
4	Pier 3: 1 foot below cap within tidal zone	5.12	1.99	0.49	-0.207
		4.57	3.15	1.19	-0.399
<u>Deck</u>					
5	Sta. 0+16 27.8 feet right	0.27	0.21	----	-0.095
6	Sta. 0+45 28.2 feet right	0.44	0.33	----	-0.065
7	Sta. 0+70 28.3 feet right	0.29	0.78	----	-0.013

(A) Reinforcing steel in the piles has 3 inches clear cover. Reinforcing steel in top of the deck has 2 inches clear cover.

CORROSION STANDARDS

A chloride content of 1.0-2.0 lb/CY is generally accepted as the threshold for corrosion.(1)

ASTM C 876-80 states "if potentials over an area are numerically greater than -0.35 V CSE, there is a 90 percent probability that reinforcing steel corrosion is occurring."

CONCLUSIONS

The average half cells indicate that there is a 90 percent probability that corrosion is occurring in reinforcing steel in the piles within the tidal zone. There is no significant difference in test results between the control piles and experimental piles. The effectiveness of DCI as a corrosion inhibitor cannot be determined from this project. The test results do confirm the supplier's previous testing which indicates that concrete containing one percent DCI only slightly delays the start of corrosion.(2)

Further field testing does not appear to be warranted. The structure will be monitored through our bridge condition inspection program and reported on at such time as any apparent corrosion is detected in either the experimental piles and slab or the control piles.

REFERENCES

1. Anderson, A. R.; and Black, R. W., "Questioning the Limit," Concrete International, V. 7, No. 9, September 1985, pp. 28-33.
Transmittal 188, Federal-Aid Highway Program Manual 6.7.2.7.12.d.(4)(d)
2. Rosenberg, A. M.; Gardis, J. M.; Kossivas, T. G.; and Previte, R. W.; "A Corrosion Inhibitor Formulated with Calcium Nitrite for Use in Reinforced Concrete," STP-629, ASTM, Philadelphia, 1977, pp. 89-99.

APPENDIX A
Mechanism of Corrosion
How DCI Works

Darex[®] Admixtures Techletter

Corrosion Inhibitors
DX80-6008

MECHANISM OF CORROSION

HOW DCI WORKS

The mechanism of corrosion is rather complex. A simplified approach to the theory of corrosion methodology we subscribe to is presented.

The corrosion of reinforcing steel is the reaction of iron metal with oxygen in the presence of moisture. The rusting of iron objects in the atmosphere produces layers of iron compounds ranging from ferrous oxide (FeO), through Fe₃O₄, to ferric oxide (Fe₂O₃). We are simplifying the discussion of the chemistry here by ignoring water which may be bound in varying amounts to the iron oxides.

In concrete, which contains high levels of hydroxyl ions and thus exhibits a relatively high pH, normal corrosion processes cause the iron rebar to become coated with a very thin layer of Fe₂O₃. This layer of Fe₂O₃ serves as a barrier which prevents iron ions from leaving the reinforcing bar. Corrosion, which is simply metal loss due to chemical processes, stops. Therefore, concrete by itself is an excellent corrosion inhibitor. You can think of iron in concrete being protected in an analogous situation similar to aluminum products in normal use when no salt is present.

However, the presence of chloride in concrete prevents the ferric oxide coat from stabilizing and, thus, allows further corrosion to proceed. The chloride ion may be integral in the concrete from the use of marine aggregates or chloride-containing admixtures, or it may enter the concrete over a period of time from the application of deicing salts containing NaCl or CaCl₂ or even from salt-laden air. The chloride ion penetrates the thin protection layer of Fe₂O₃ and forms complexes with ferrous ion (Fe⁺⁺) at the steel surface. These iron-chloride complexes are solubilized and move into the concrete. The ferrous ion eventually precipitates as Fe(OH)₂ (=FeO·H₂O) and oxidizes to Fe₂O₃. Meanwhile, the chloride ion, which has been freed from the complex by the precipitation, goes back through the Fe₂O₃ layer to cause more corrosion. Eventually, the film of Fe₂O₃ is so undermined that it offers no protection.

The diffusion of the iron-chloride complex away from the reinforcing steel and the production of solid corrosion products with a fourfold volume increases causing a disruptive splitting force. This expansion force easily overcomes the relatively weak tensile strength of the concrete, resulting in popouts, spalls, and general disruption of the concrete. This blitz-like attack can result in complete failure of a reinforced concrete system.

(Cont'd.)

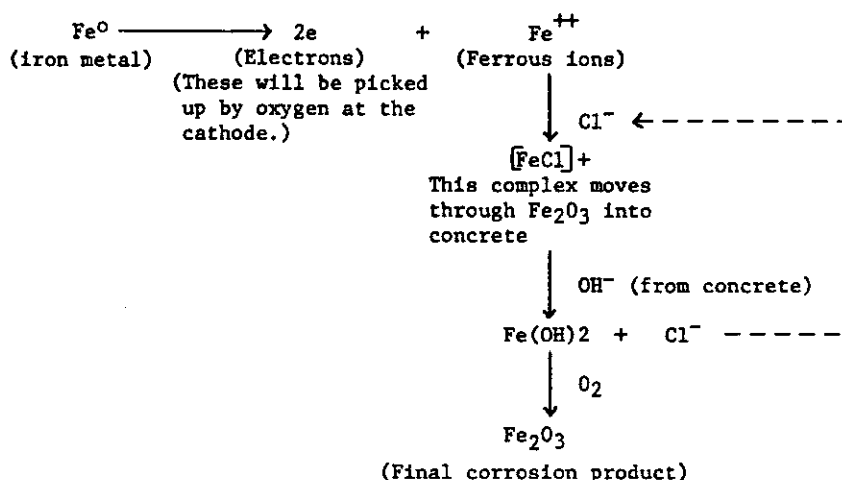
We hope the information given here will be helpful. It is based on data and knowledge considered to be true and accurate and is offered for the user's consideration, investigation and verification. Please read all statements, recommendations or suggestions in conjunction with our conditions of sale which apply to all goods supplied by us. No statement, recommendation or suggestion is intended for any use which would infringe any patent or copyright. Construction Products Division, W.R. Grace & Co., 62 Whittemore Ave., Cambridge, Mass. 02140

GRACE
CONSTRUCTION PRODUCTS DIVISION

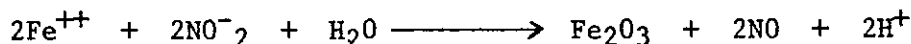
DAREX CORROSION INHIBITOR, based on calcium nitrite, acts to inhibit corrosion through its unique oxidizing properties in the presence of iron. Remember, the presence of chloride ion allowed movement of ferrous (Fe^{++}) complexes through the concrete. The nitrite ion (NO_2^-), however, immediately oxidizes ferrous ions (Fe^{++}) to the more insoluble ferric (Fe^{+++}) state and in so doing, reinforces the thin layer of Fe_2O_3 (ferric oxide) already present. The iron is not carried away into the concrete, but builds up a thicker layer of Fe_2O_3 which is a barrier to chloride ion migration. Corrosion is inhibited by the nitrite portion of DCI and the buildup of deleterious corrosion products is prevented as long as inhibitor is present. The calcium portion of DCI is very compatible with concrete and contributes strength enhancement and does not add to alkali-aggregate expansion.

In summary, in concrete, iron is protected from corrosion by a thin layer of Fe_2O_3 which prevents loss of iron ions.

In the presence of Cl^- ion, this layer is penetrated and metal loss (corrosion) occurs:



In the presence of nitrite ion, the $[FeCl]^+$ complex is precipitated at the point where Fe_2O_3 film is being penetrated, strengthening the film and making it resistant to chloride penetration. The equation for oxidation of ferrous to ferric is:



Therefore, it has been shown that calcium nitrite added in sufficient quantity to reinforced concrete which may contain contamination from chloride salts produces a stable iron oxide film preventing the formation of the highly disruptive corrosion products normally produced by the chloride.

APPENDIX B
Change Order No. 2

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

AUG 06 1981

Sheet 1 of 2
Date 7/23/81

CHANGE ORDER

Change Order Number 2

Ordered by Engineer under terms of Section 1-04.4 of the Standard Specifications

Change proposed by Contractor

2055

Hurlen Construction Co.
P. O. Box 30945
Seattle, Wa. 98108

SR 308
BRF 308(2)

Dogfish Bay Bridge 308/51
Replacement

Endorsed by: Hurlen Construction Co.
Contractor Firm Name

[Signature]
Signature

30 July
Date

Title PRESIDENT

Consent given by Surety: (when required)

By: _____
Attorney-in-fact

_____ Date

DESCRIPTION OF WORK

You are ordered to perform the following described work upon receipt of an approved copy of this change order:

Add Darex Corrosion Inhibitor (DCI) to all concrete used in the pre-stressed concrete piles, excluding the test piles, and in the pre-stressed roadway slabs. The DCI shall be added in accordance with the Manufacturer's recommendations (2% x cement weight) and as directed by the Engineer.

The lump sum cost for "Darex Corrosion Inhibitor" shall be full compensation for all labor, materials and equipment required to furnish and introduce the DCI into the concrete mix.

Discussed with and approved by John Garren July 22, 1981.

All work, materials and measurement to be in accordance with the provisions of the Standard Specifications and Special Provisions for the type of construction involved.

<input type="checkbox"/> DISTRICT APPROVAL REQUIRED <input type="checkbox"/> HEADQUARTERS APPROVAL REQUIRED	ORIGINAL CONTRACT AMOUNT	CURRENT CONTRACT AMOUNT	ESTIMATED NET CHANGE THIS ORDER	ESTIMATED CONTRACT TOTAL AFTER CHANGE
	\$ 256,559.00	\$ 260,210.00	\$ 7525.00	\$ 267,835.00

DISTRICT USE

APPROVAL RECOMMENDED

[Signature]
Professional Engineer

7/25/81
Date

HEADQUARTER'S USE

APPROVED:

BY *[Signature]*
FCR Highway Construction Engineer

8/18/81
Date

APPROVAL RECOMMENDED APPROVED

DISTRICT ADMINISTRATOR A.R. Morrill

By: *[Signature]* Date: 8-5-81

DEPARTMENT OF TRANSPORTATION
INTRA-DEPARTMENTAL COMMUNICATION

DATE: August 5, 1981

FROM: A. R. Morrell/D. L. Barclay

Phone:

SUBJECT: SR 308
Dogfish Bay Bridge 308/51
- Replacement
Contract 2055

To: T. G. Gray/M. J. Nash
KF-01

Attached for your signature is Change Order No. 2 which provides for the addition of Darex Corrosion Inhibitor to all concrete used in the prestressed concrete piles and in the prestressed roadway slabs. This addition was requested by Headquarters Bridge with the concurrence of the FHWA.

The breakdown for the cost to add the DCI is:

Material Cost	\$27.00*
Waste, Testing, Dispenser Rental & Setup	<u>9.50</u>
Subtotal	\$36.50
15% P & OH (Fabricator)	5.48
15% P & OH (Prime)	<u>5.48</u>
	\$47.46/CY of Concrete AX

* Bridge Division estimate = \$24.62

160 CY x \$47.46/CY = \$7,593.60

Verbal approval for this addition was received from Tom Murawski July 22, 1981.

ARM/mtc
DLB/EDS
Attach.
cc: M. H. Holgerson

TESTING LABORATORIES, INC.

CONSTRUCTION MATERIALS

INVESTIGATION

DESIGN AND CONTROL

CONSULTATION

RESEARCH

1945 EAST 87TH STREET
CHICAGO, ILLINOIS 60617

November 21, 1979

Re: Darex Corrosion Inhibitor
ASTM C 494-77a

Our data on the Darex Corrosion Inhibitor used in the calculations in the test mix are as follows;

Specific Gravity 60/60°	1.296
pH	9.3
Solids, % By Weight	32.4

The enclosed results indicate that Darex Corrosion Inhibitor added at approximately 2.0% by weight of cement, solids to solids complies with ASTM C 494-77a.

Included with this report is a summary data of the average results to date followed by individual tests results.

We would be pleased to discuss this report with you at your convenience.

Respectfully submitted,

FLOOD TESTING LABORATORIES, INC.

Walter H. Flood

Walter H. Flood

REPORT OF TEST OF

Design OF Concrete Mixture

LABORATORY NO. _____ DATE November 23, 1979
 SAMPLED BY: _____ Page No. 14
 SAMPLED FROM: _____ AMOUNT _____
 MANUFACTURED BY: _____
 CONTRACTOR: Construction Products Division
 W.R. Grace & Company
 6051 West 65th Street
 REMARKS: Chicago, Illinois 60638
 Att: Mr. Leo Rojic

Project:	D.C.I. Test Mix		
Material:	Coarse Aggregate		Fine Aggregate
Type:	No.57 Crushed Stone (Regraded)		Natural Sand (Regraded)
Design Data:			
Bulk Specific Gravity(Sat.Surf.Dry)	2.70		2.68
Wt./Cubic Foot, Dry Rodded,lbs.:	96.8		112.4
Voids in Aggregate, %	42.5		32.8
Absolute Volume of Coarse Aggregate per Cubic Foot of Mortar		0.64	
Absolute Volume of Mortar per Dry Rodded Cubic Foot of Coarse Aggregate		0.89	
Corrections: Coarse Aggregate in Sand, %	0.0		
Sand in Coarse Aggregate, %			0.0
			Absolute Volume
<u>Computed Mix Data</u>	<u>Per Cubic Yard</u>	<u>Per Sack Cement</u>	<u>Cu.Ft./Cu.Yd.</u>
Sacks of Cement	5.50	1.0	
Brand of Cement	See Note		
Weights(Sat.Surf.Dry),lbs.:			
Cement	517	94.0	2.63
Sand (Regraded)	1350	245.5	8.07
No. 57 Crushed Stone(Regraded)	1782	324.0	10.58
Total Water	235	42.7	3.77
Admixture: Darex Corrosion Inhibitor	3.45 gallons*	0.627 gallons	0.46
Darex AFA	8.0 fl.oz.	1.5 fl.oz.	
Air, Content Net %	5.5		1.49
Slump, Inches	2 1/2		
Water-Cement Ratio,Cals./Sack:	5.67*		
Yield: Cu.Ft./Volume of Cement	27.00	4.91	27.00
Wt./Cubic Foot of Concrete,lbs.:	145.2		
Dry Rodded Cubic Feet of Coarse Aggregate Per Unit Volume of Concrete)	0.682		
Note: Cement was blend of equal parts by weight of Universal Type I, Penn-Dixie Type I and Marquette Type I. * 3.45 gallons of D.C.I. contains 12.07 lbs. of solids and 25.18 lbs. of water. Water in D.C.I. solution used to determine water-cement ratio.			

WHF:lg

APPENDIX C
Change Order No. 3

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

NOV 12 1981

Sheet 1 of 3
Date 10/21/81

Change Order Number 3

CHANGE ORDER

Ordered by Engineer under terms of Section 1-04.4 of the Standard Specifications

Change proposed by Contractor

Contract No. 2055

Hurlen Construction Company
P. O. Box 80945
Seattle, Washington 98108

Endorsed by: Hurlen Construction Company

Garold L. G... [Signature]
Signature _____ Date 28 OCT 81

Title PRESIDENT

Consent given by Surety: (when required)

By: _____
Attorney-in-fact _____ Date _____

SR 308
BRF-308(2)
Dogfish Bay Bridge 308/51
Replacement

DESCRIPTION OF WORK

You are ordered to perform the following described work upon receipt of an approved copy of this change order:

Install wiring and connections to the cross beam and traffic barrier at the west half of pier 2 as detailed on sheet 3 of 3 of this change order.

All materials required, as delineated on sheet 3 of 3 shall be in accordance with the requirements of the Standard Specifications for the item specified, A supplier for the ~~cadweld~~ sleeve will be provided by the Project Engineer.

The lump sum item "Corrosion Monitor System" shall be full compensation for all labor, materials, and equipment necessary to perform the work as detailed in this change order.

The contract time is extended 3 working days to complete this item of work.

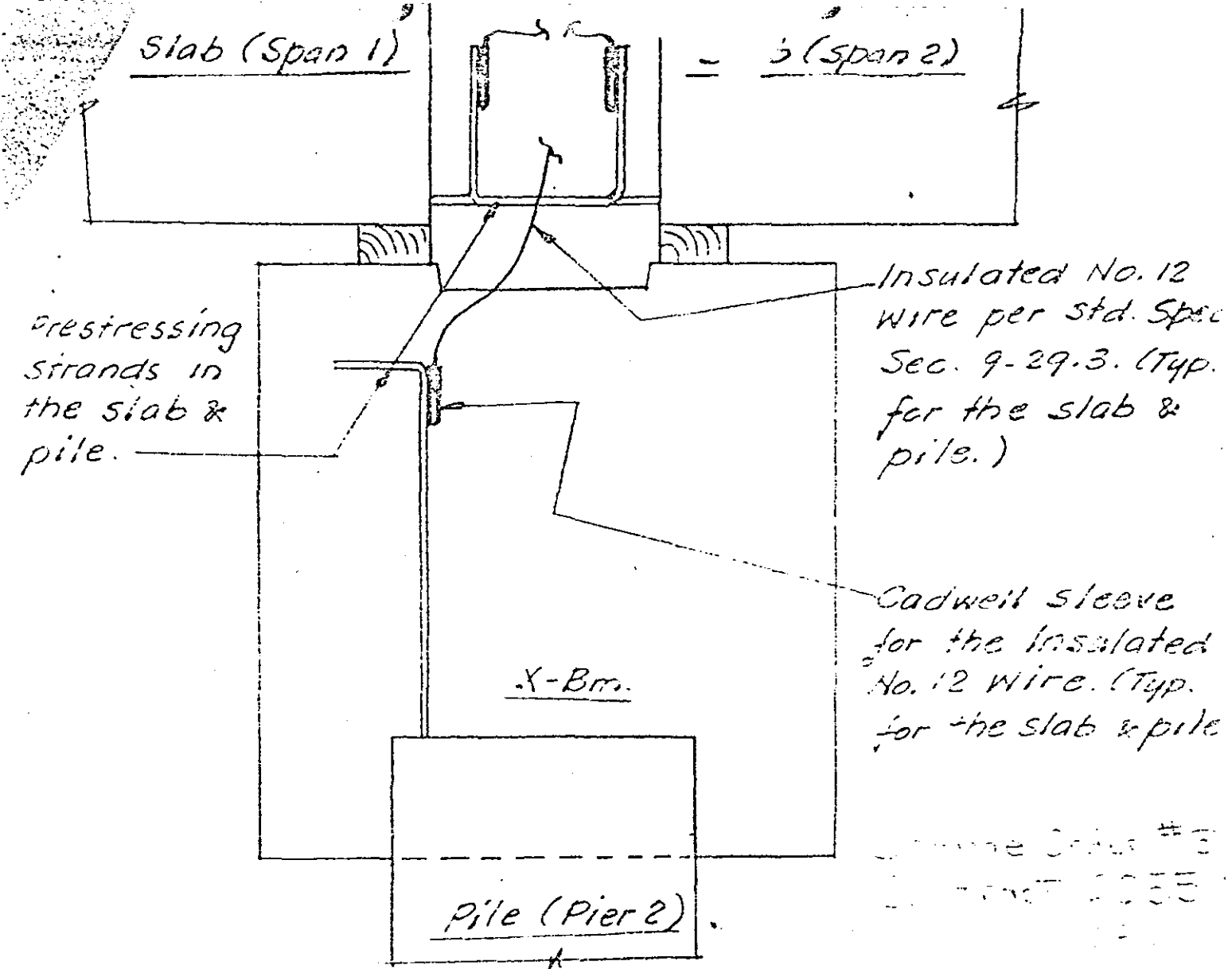
All work, materials and measurement to be in accordance with the provisions of the Standard Specifications and Special Provisions for the type of construction involved.

<input type="checkbox"/> DISTRICT APPROVAL REQUIRED <input checked="" type="checkbox"/> HEADQUARTERS APPROVAL REQUIRED	ORIGINAL CONTRACT AMOUNT	CURRENT CONTRACT AMOUNT	ESTIMATED NET CHANGE THIS ORDER	ESTIMATED CONTRACT TOTAL AFTER CHANGE
	\$ 256,599.00	\$ 267,835.00	\$ 971.00	\$268,806.00

DISTRICT USE
APPROVAL RECOMMENDED
Project Engineer _____ Date _____

HEADQUARTER'S USE
APPROVED: *[Signature]*
Highway Construction Engineer _____ Date _____

APPROVAL RECOMMENDED APPROVED
DISTRICT ADMINISTRATOR [Signature]
By: [Signature] Date: 11-10-81



Insulated No. 12 Wire per std. Spec. Sec. 9-29.3. (Typ. for the slab & pile.)

Cadwell sleeve for the Insulated No. 12 Wire. (Typ. for the slab & pile)

prestressing strands in the slab & pile.

X-Bm.

Pile (Pier 2)

Slab (Span 1)

Slab (Span 2)

Notes:

1. Install at Pier 2, 2 Cadwell sleeve and 2 No. 12 wire to the prestressing strands of:
 - a. The outer and innermost piles.
 - b. The outer and innermost slab of spans 1 & 2.
2. Check the connection for any deficiency.
3. Epoxy coat the connections.
4. Bring lead wires into a J-Box mounted on the exterior face of the west traffic barrier @ Pier No. 2.
5. Number wires with identification tags and identify location of strand to which wire is attached.
6. Provide conduit from end of X-BM to J-Box. End of conduit to be embedded 6" into X-BM.

Cadwell sleeve

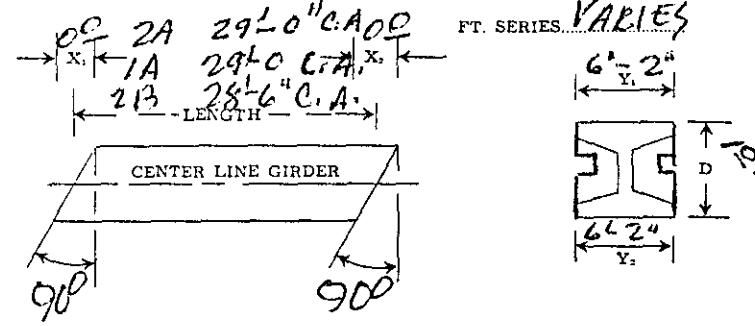
8/11

APPENDIX D
Prestressed Slab Reports

2R-0's

PRESTRESSED CONCRETE GIRDER REPORT NO. 1

CONT. NO. 2055 F. A. NO. BRP-308 (2) HWY. NO. S. R. 308 CONC. MIX 11A AGGREG. SOURCE PITD47
 SECTION DOG FISH Bay BRIDGE REPLACEMENT % SAND PASSING #16 64³ % GRAVEL PASSING #4 96.2
 BRIDGE NAME DOG FISH CONTR. HURLEN BUSTO CEM. BRAND IDEAL TYPE III SKS./CY 7 1/4 WATER G.P.S. 45



PRETENSION CABLES: SUMMIT WIRE PRODUCTS
 LOT NO. SEE REMARKS REEL NO. BELOW
 STRGHT. CABLE NO. 29 SIZE 1/2 220K HRPD. CABLES NO. N/A SIZE
 STRGHT. JACK FORCE 28,900 LBS./CABLE 838,100 LBS. TOTAL
 ELONGATION CALCULATED 24 3/8" MEASURED 24 3/8"
 HRPD. JACK FORCE N/A LBS./CABLE N/A LBS. TOTAL
 ELONGATION CALCULATED MEASURED
 PRE-TENSION RELEASE DATE 8-17-81 TIME 0:30

REMARKS 42 1/2 OZS OF D.C.I. IN MIX PER 100 LBS CWT & 40 OZS P633 300R/10.4d

GIRDER NO.	DATE POURED	POUR TIME		AIR TEMP.	CONC. TEMP.	SLUMP	CURING		CYL. NO.	DATE TESTED	AGE HRS.	PSI	Camber	FINISHED LENGTH	REMARKS
		BEGIN	END				Hr. Steam	Avg. Temp.							
2B-1	8-14-81	1015	1045	73°	83°	3 3/4"	12	115°	CTR	8-17-81	168 3/4	5060	+2 7/32"	28'-6 1/4"	KD 216 14224-A-V1815
1A-3	8-12-81	1515	1540	87°	82°	3"	10 1/2	148°	CTR	8-17-81	14 1/2	5555	-1 1/32"	29'-0 1/8"	14226-C-V1813+
2A-2	8-13-81	1400	1430	85°	82°	3 1/4"	16	153°	CTR	8-17-81	89	5570	+1"	29'-0 1/8"	KD 217
1A-2	8-11-81	1545	1615	73°	81°	3 1/4"	14 1/2	156°	CTR	8-17-81	135 1/4	5570	+3/4"	29'-0 3/8"	14224A V1815
2A-1	8-11-81	1512	1540	73°	82°	2 3/4"	14 1/2	149°	CTR	8-12-81	15	5235	+1 1/32"	29'-0 1/8"	14234C V1817+
1A-1	8-10-81	1330	1405	93°	85°	3 1/2"	12	152°	N/S	8-17-81	16 3/4	5305 5535	+1 1/32"	29'-0 1/8"	109°

5000 PSI AT REL
 6000 " AT 28 DAY

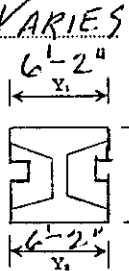
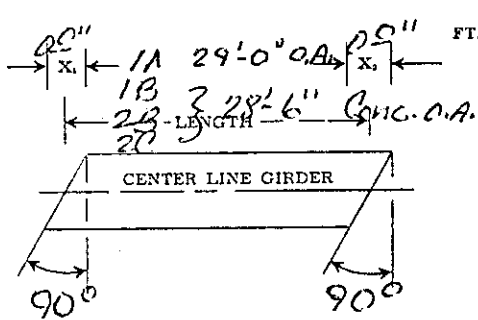
REMARKS Made at Univ. of Ill. C. Everett

* Camber at center of girder

PROJ. ENGR. HOLLERSON
 FIELD INSP. NELSON/SATHER
 DATE 8-17-81

PRESTRESSED CONCRETE GIRDER REPORT NO. 2

CONT. NO. 2055 F. A. NO. BRE-308 (2) HWY. NO. 308 CONC. MIX. 11A AGGREG. SOURCE PITDUY
 SECTION DOG FISH BAY BRIDGE REPLACEMENT % SAND PASSING #16 64 % GRAVEL PASSING 3/4" 98.5
 BRIDGE NAME DOG FISH CONTR. HURLLEN CONST. CEM. BRAND IDEAL TYPE III SKS./CY 7 1/4 WATER G.P.S. 4.5 +



PRETENSION CABLES: Sumiden Wire Prods Corp
 LOT NO. SEE REMARKS REEL NO. BELOW
 STRGHT. CABLE NO. 29 SIZE 1/2 270T HRPD. CABLES NO. N SIZE A
 STRGHT. JACK FORCE 28,900 LBS./CABLE 838,106 LBS. TOTAL
 ELONGATION CALCULATED 24 3/8" MEASURED 24 3/8"
 HRPD. JACK FORCE _____ LBS./CABLE _____ LBS. TOTAL
 ELONGATION CALCULATED _____ MEASURED _____
 PRE-TENSION RELEASE DATE 8-21-81 TIME 17800

REMARKS _____

GIRDER NO.	DATE POURED	POUR TIME BEGIN	END	AIR TEMP.	CONC. TEMP.	SLUMP	CURING		CYL. NO.	DATE TESTED	AGE HRS.	PSI	Camber	FINISHED LENGTH	REMARKS
							Hr. Steam	Avg. Temp.							
2C-2	8-20-81	1600	1645	70	75	2 1/2	12	145°	AVG	8-21-81	13 1/4	5430	1 3/32	28' 6"	KC10 13897B V1608
1B-2	8-20-81	1500	1545	70	75	2 1/2	12	114°	AVG	8-21-81	14 3/4	5625	2 1/32	28' 6"	KA119 13926B V1607+
2C-1	8-19-81	3:30pm	4:00pm	77°	78°	3"	10	140°	CTR	8-20-81	14 1/2	6120	1 3/32	28' 6"	13941B V1605
1B-1	8-19-81	3:00pm	3:20pm	77	78°	3"	12	145°	CTR	8-20-81	15 1/4	5675	3/41	28' 6"	13942B V1606
2B-2	8-18-81	1600	1620	90°	81°	3 1/8	16	140°	CTR	8-19-81	14 1/2	5250	1 7/32	28' 6"	KA155 14006B V1610+
1A-4	8-18	1255	1315	85°	80°	3"	16	140°	CTR	8-19-81	17 1/2	5375	1 3/32	29' 0"	KD217 14234A V1815+

5000 PSI AT REL
 MATLS. LAB. 6000 " AT 28 days

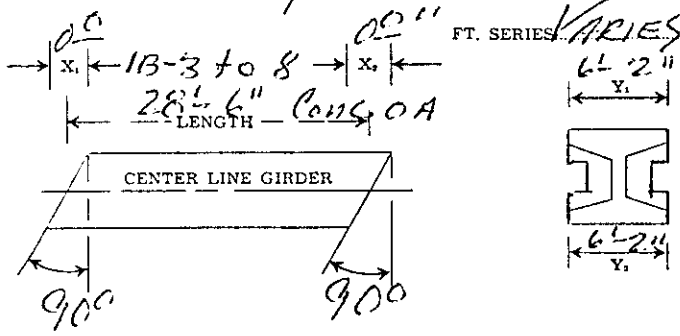
REMARKS Made @ Assoc. with
Co. Everett

* Camber at center of girder

PROJ. ENGR HOLLERSON
 FIELD INSP NELSON/SATHER
 DATE 8-21-81

PRESTRESSED CONCRETE GIRDER REPORT NO. 3

CONT. NO. 2055 F. A. NO. BRF-308(2) HWY. NO. _____ S. R. 308 CONC. MIX 11A AGGREG. SOURCE PIT D47
 SECTION DOG FISH BAY BRIDGE REPLACEMENT % SAND PASSING #16 64.3 % GRAVEL PASSING 3/4" 97.0
 BRIDGE NAME DOG FISH BAY CONTR. HURLEN Const Co CEM. BRAND IDEAL TYPE III SKS./C.Y. 7 1/4 WATER G.P.S. 4.5+



PRETENSION CABLES: SUMIDEN WIRE PRODS Corp
 LOT NO. SEE REMARKS REEL NO. BELOW
 STRGHT. CABLE NO. 29 SIZE 1/2" x 7/16" STRGHT. JACK FORCE 28,900 LBS./CABLE 838,100 LBS. TOTAL
 ELONGATION CALCULATED 24.3/8" MEASURED 24.3/8"
 HRPD. JACK FORCE _____ LBS./CABLE _____ LBS. TOTAL
 ELONGATION CALCULATED _____ MEASURED _____
 PRE-TENSION RELEASE DATE 8-31-81 TIME 0.530

REMARKS 12 1/2 cys OF D.C.I. / PUT IN
Mix of 38 cys Pozz 300K / c. yd.

GIRDER NO.	DATE POURED	POUR TIME		AIR TEMP.	CONC. TEMP.	SLUMP	CURING		CYL. NO.	DATE TESTED	AGE HRS.	PSI	Camber	FINISHED LENGTH	REMARKS
		BEGIN	END				Hr. Steam	Avg. Temp.							
1B-3	8-25-81	1025	1050	66°	77°	2 7/8	11	100°	14R	8-26-81	19 3/4	5660	5/16"	28'-8 7/8"	KD 217 14234R-V1816
1B-4	8-25-81	1105	1135	71°	77°	3 1/4	8	102°	14R	8-26-81	19 1/4	5090	7/16"	28'-5 3/4"	KD 324 14931-V2001
1B-5	8-26-81	1500	1520	80°	79°	3"	5	128°	14R	8-31-81	110 3/4	6065	2 1/8"	28'-5 3/4"	14932-V2002
1B-6	8-26-81	1650	1707	72°	77°	2 7/8	6	127°	14R	8-27-81	13	5555	1/2"	28'-5 7/8"	14933-V2003
1B-7	8-27-81	1425	1450	73°	77°	3 1/2	8	117°	14R	8-31-81	8 3/4	5605	2 1/8"	28'-6"	14936-V2004
1B-8	8-28-81	0900	0925	68°	75°	3"	4	131°	14R	8-31-81	6 1/4	6120	5/8"	28'-5 1/2"	KA 119 13941B-V1605+

5000 PSI AT REL.
 6000 PSI AT 28 DAY

REMARKS Made @ Assoc. (A&L)
C. Greenett

* Camber at center of girder

PROJ. ENG'R HOLLERSON
 FIELD INSP. NEZSON
 DATE 8-31-81

APPENDIX E
Prestressed Pile Reports

PRESTRESS PILE RECORD

Highway No. 308 Section DOG FISH BAY BRIDGE REPLACEMENT 303/157
 Contract No. 2055 Report No. 6 Outside Diameter 16 1/2" Wall Thickness N/A
 Pre-Tension Cables: Lot No. BELOW Reel No. BELOW Straight Cables: No. 15 Size 1/2" ϕ 270 K
 Elongation: Calculated 15" Measured 15" Straight Jacking Force 28900 Lbs./Cable 433,500 Total Lbs.

Pile Number	Cast Length	Date Pour	Begin Pour	End Pour	Air Temp.	Conc. Temp.	Slump (in.)	Avg. Temp. Curing	Hrs. of Cure		Cyl. Nos.	Date Broke	P. S. I.	Destress Date/Time	Finished Length
									Steam	Water					
SP21	31'0"	8-19-81	140PM	225PM	77	78	3"	130°	39 1/2		N	8-21-81	6870	6800	31'0"
SP22	"	[Handwritten squiggles]	[Handwritten squiggles]	[Handwritten squiggles]	[Handwritten squiggles]	[Handwritten squiggles]	[Handwritten squiggles]	"	"		S	"	7305		"
23	"							"	"	AVG	"	7085		"	
24	"							"	"					"	
SP25	"							"	"					"	

Remarks: HEAT# KD119 Coll # 13941 B V1605
" KD 217 " 14234 B V1816

Dist: Bridge Engineer
 County Engineer
 Materials McHANEY
 District Engineer
 Resident Engineer
 Field Inspector

NELSON / SATHER 8-21-81
 Field Inspector

PRESTRESS PILE RECORD

Highway No. 308 Section DOGFISH BAY BRIDGE REPLACEMENT 308/151
 Contract No. 2055 Report No. 5 Outside Diameter 16 1/2" Wall Thickness N/A
 Pre-Tension Cables: Lot No. BELOW Reel No. BELOW Straight Cables: No. 15 Size 1/2" 270K
 Elongation: Calculated 15" Measured 15" Straight Jacking Force 28,900 Lbs./Cable 423,500 Total Lbs.

Pile Number	Cast Length	Date Pour	Begin Pour	End Pour	Air Temp.	Conc. Temp.	Slump (in.)	Avg. Temp. Curing	Hrs. of Cure		Cyl. Nos.	Date Broke	P. S. I.	Destress Date/Time	Finished Length
									Steam	Water					
4P-16	31'-0"	8-17-81	1400	1450	81°	80°	2 3/4				S	8-18-81	6030	8-11-81 0815	31'-0 1/4
4P-17	31'-0"	"	"	"	"	"	"								31'-0 1/4
4P-18	31'-0"	"	"	"	"	"	"								31'-0 1/4
4P-19	31'-0"	"	"	"	"	"	"				N	8-18-81	5625		31'-0 1/4
4P-20	31'-0"	"	"	"	"	"	"					AVG	5528		31'-0 1/4

Remarks: KA119-13926B-V1607, 13942B-V1606, KA155-14006B-V1610
 KA010-13897B V1608 380zs Pizz 300K/10.4d & 42 1/2 OZS
 DCI PER 100# CWT MADE AT ASSOC. S&G. CO. LEVERETT

Dist.: Bridge Engineer
 County Engineer
 Materials
 District Engineer
 Resident Engineer
 Field Inspector

5500 PSI AT REL.
 7000 " AT 283day

NELSON / SATHER 819
 Field Inspector Date

PRESTRESS PILE RECORD

Highway No. 308 Section DOG FISH BAY BRIDGE REPLACEMENT 308/151
 Contract No. 2055 Report No. 4 Outside Diameter 16 1/2" Wall Thickness N/A
 Pre-Tension Cables: Lot No. BELOW Reel No. BELOW Straight Cables: No. 15 Size 1/2" 270K
 Elongation: Calculated 15" Measured 15" Straight Jacking Force 28,900 Lbs./Cable. 433,500 Total Lbs.

Pile Number	Cast Length	Date Pour	Begin Pour	End Pour	Air Temp.	Conc. Temp.	Slump (in.)	Avg. Temp. Curing	Hrs. of Cure		Cyl. Nos.	Date Broke	P. S. I.	Destress Date/Time	Finished Length
									Steam	Water					
3P-11	31'-0"	8-15-81	10:30	11:10	65°	80°	2 7/8	28	160°		N	8-17-81	N 6420	8-17-81 8:00AM	31'-0 1/4"
3P-12	31'-0"	"	"	"	"	"	"					"	S 6470	"	31'-0 1/4"
3P-13	31'-0"	"	"	"	"	"	"					"	AVG 6445	"	31'-0 1/4"
3P-14	31'-0"	"	"	"	"	"	"					"	"	"	31'-0 1/4"
3P-15	31'-0"	"	"	"	"	"	"	26	140°		S	"	"	"	31'-0 1/4"

Remarks: KA 119 - 13926 B - V1607 - 13942 - V1606 KA 155 - 14006 B - V1610
 KA 010 - 13897 B V1608 - 38 cya Pozz3300R/ci yd @ 42 1/2. OES DCI
 PER 100# CMT. MADE AT ASSOC S & G CO - EVERETT

Dist.: Bridge Engineer
 County Engineer
 Materials
 District Engineer
 Resident Engineer
 Field Inspector

5500 PSI AT REL
 7000 PSI AT 28 days

NELSON/SATHER
 Field Inspector Date 8-17-81

PRESTRESS PILE RECORD #3

Highway No. 308 Section DOG FISH BAY BRIDGE REPLACEMENT
 Contract No. 2055 Report No. 2 Outside Diameter 16 1/2" Wall Thickness N/A
 Pre-Tension Cables: Lot No. BELOW Reel No. BELOW Straight Cables: No. 15 Size 1/2 4270K
 Elongation: Calculated 15" Measured 15" Straight Jacking Force 28,900 Lbs./Cable 433,500 Total Lbs.

Pile Number	Cast Length	Date Pour	Begin Pour	End Pour	Air Temp.	Conc. Temp.	Slump (in.)	Avg. Temp. Curing	Hrs. of Cure		Cyl. Nos.	Date Broke	P. S. I.	Destress Date/Time	Finished Length
									Steam	Water					
2P-6	31'-0"	8-13-81	1535	1610	86	84	2 1/2	135°	34		3	8-15-81		8-15-81	31'-0 1/4"
2-7	31'-0"	"	"	"	"	"	"	"				8-15-81			"
2P-8	31'-0"	"	"	"	"	"	"	"							"
2P-9	31'-0"	"	"	"	"	"	"	"							"
2P-10	31'-0"	"	"	"	"	"	"	120°	34						"
												5640			
												AVG 5598			

Remarks: KD 216 - 142250 - V1811 & KD 217 - 14234B V1816 - SUMMIT
USIN D.C.T. IN MIX 4 2 1/2 cgs / 100# CNT & 40 cgs 300K / C. 4/6
MADE AT ASSOC S & G. CO.

DIST.: Bridge Engineer
 County Engineer
 Materials
 District Engineer
 Resident Engineer
 Field Inspector

5500 AT REL
7000 PSI AT 28 DAY
(INCLUDES SHIPPING)

W. B. Nelson & S. L. Lather 8-15-81
 Field Inspector Date

RECORD

PRESTRESS PILE RECORD

Highway No. 308 Section DOG FISH BAY BRIDGE REPLACEMENT
 Contract No. 2055 Report No. 2 Outside Diameter 16 1/2" Wall Thickness 1/2"
 Pre-Tension Cables: Lot No. BELOW Reel No. BELOW Straight Cables: No. 15 Size 1/2 270K
 Elongation: Calculated 15" Measured 15" Straight Jacking Force 74,900 Lbs./Cable 1,135,500 Total Lbs.

Pile Number	Cast Length	Date Pour	Rein Pour	End Pour	Air Temp.	Conc. Temp.	Slump (in.)	Avg. Temp. Curing	Hrs. of Cure Steam	Water	Cyl. Nos.	Date Broke	P.S.I.	Distress Date/Time	Finished Length
P1-1	31'-0"	8/18/81	1550 WSD	80°	54°	3 1/4"	12-139	N	3-81	5500	8-19-81	31'-0 1/4"			
P1-2	31'-0"	"	"	"	"	"	"	"	"	"	"	"			
P1-3	31'-0"	"	"	"	"	"	"	"	"	"	"	"			
P1-4	31'-0"	"	"	"	12	145°	"	"	"	"	"	"			
P1-5	31'-0"	"	"	"	"	"	"	S	8-18-81	5500	"	"			
									AVE	5500	"	"			

Remarks: RP 216 Coil 142250 K111 KP 155 Coil 1400618 V1610
USING D.C.I. IN MIX 42% 235 / CUT & 40% 300R / C. 9d
MADE AT ASSOC BAY CO EVENT

Disc: Bridge Engineer
 County Engineer
 District Engineer
 Reel No. Engineer
 Field Inspector

5500 PSI AT REL
 7000 " @ 28 Day

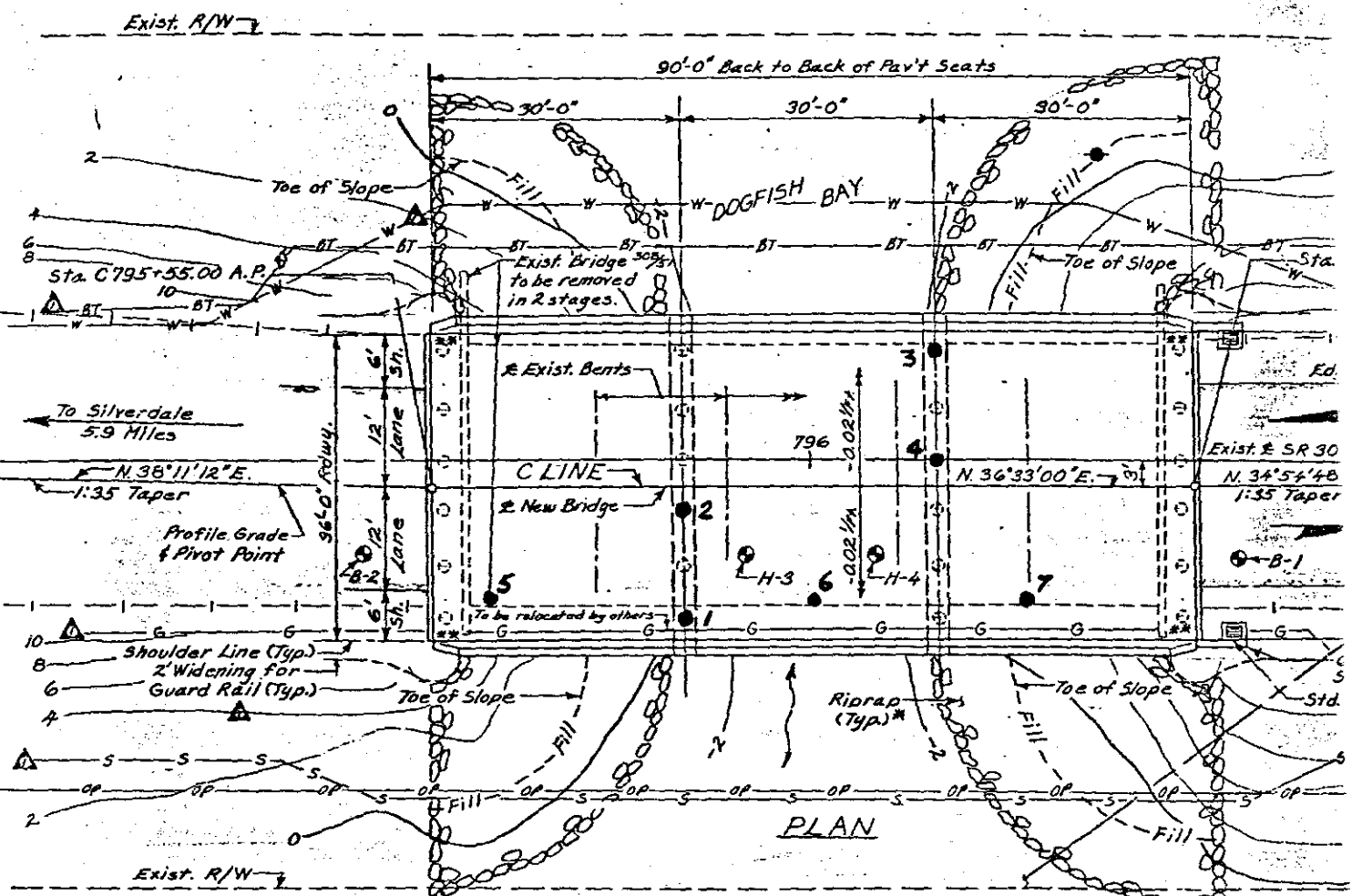
Nelson/SATHERC
 Field Inspector

8-13-81

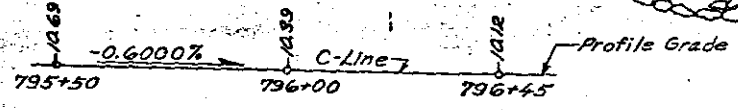
APPENDIX F
Bridge Layout

SEC. 35, T. 26 N., R. 1 E., W. M

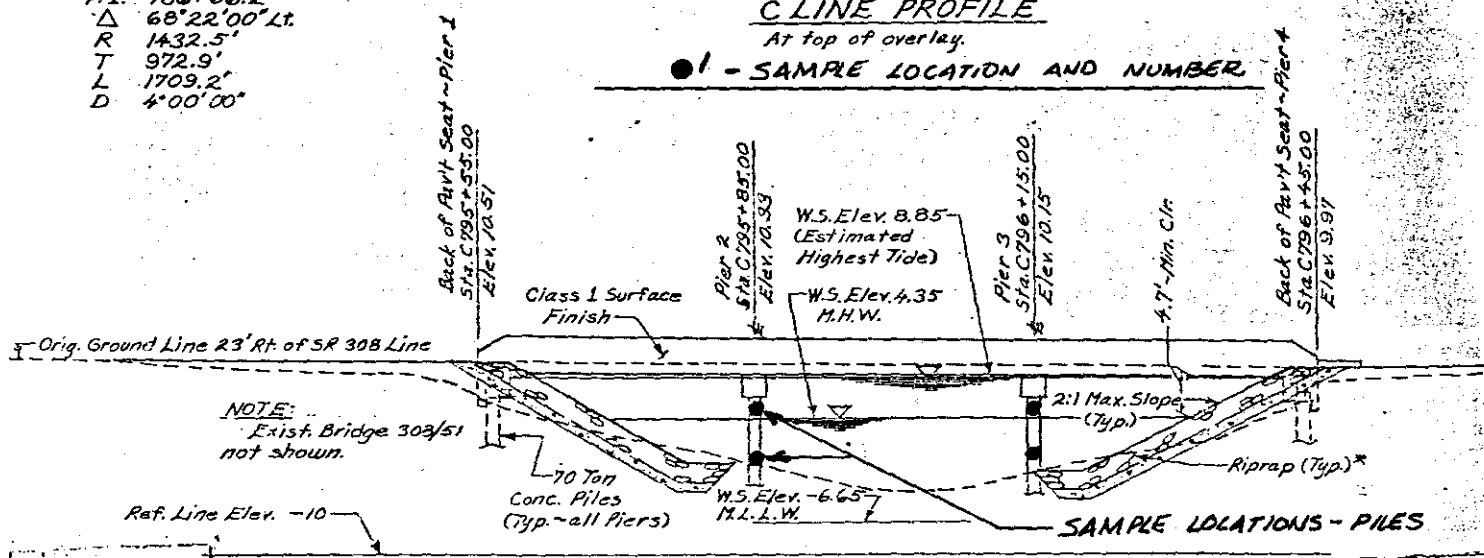
5-80	Layout By	Z.Y.F.
5-80	Layout Checked By	J.E.D.
5-80	Bridge Architect	R.M.A.S.
5-80	Checked By	D.M. 12/7/85
5-80	Design Checked By	D.M. 12/7/85
5-80	Drawn By	D.M. 12/7/85
5-80	Engineer of Bridge Design	D.M. 12/7/85
5-80	Supervising Bridge Eng.	D.M. 12/7/85
5-80	Reviewed By	D.M. 12/7/85
5-80	BY	APPD
5-80	REVISION	
5-80	DATE	
5-80	APP'D	
5-80	DATE	
5-80	REVISION	
5-80	DATE	
5-80	REVISION	
5-80	DATE	



CURVE DATA
 P.I. 786+66.2
 Δ 68°22'00" Lt.
 R 1432.5'
 T 972.9'
 L 1709.2'
 D 4°00'00"



● 1 - SAMPLE LOCATION AND NUMBER



DATUM
 Nat'l. Grad. Vert. Datum of 1989

ELEVATION
 Grade elevations shown are finish grades @ top of concrete on C-Line and are 0.15' below profile grade.

