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

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
WA-RD 104.1		

4. TITLE AND SUBTITLE

EFFECTIVENESS OF DAREX CORROSION INHIBITOR IN PREVENTING CONCRETE DETERIORATION

5. REPORT DATE

January, 1987

6. PERFORMING ORGANIZATION CODE

WA 81-01

7. AUTHOR(S)

Ed Henley

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Washington State Department of Transportation
Olympia, WA 98504

10. WORK UNIT NO.

11. CONTRACT OR GRANT NO.

13. TYPE OF REPORT AN PERIOD COVERED

Final Report

12. SPONSORING AGENCY NAME AND ADDRESS

Washington State Department of Transportation
Olympia, WA 98504

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

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.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
Darex Corrosion Inhibitor, DCI, Calcium Nitrite, chloride, bridge substructure	

19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
Unclassified	Unclassified	32	

DOT FORM 310-022 (11/86) -1216-

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

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SR 308

DOGFISH BAY BRIDGE 308/51 REPLACEMENT

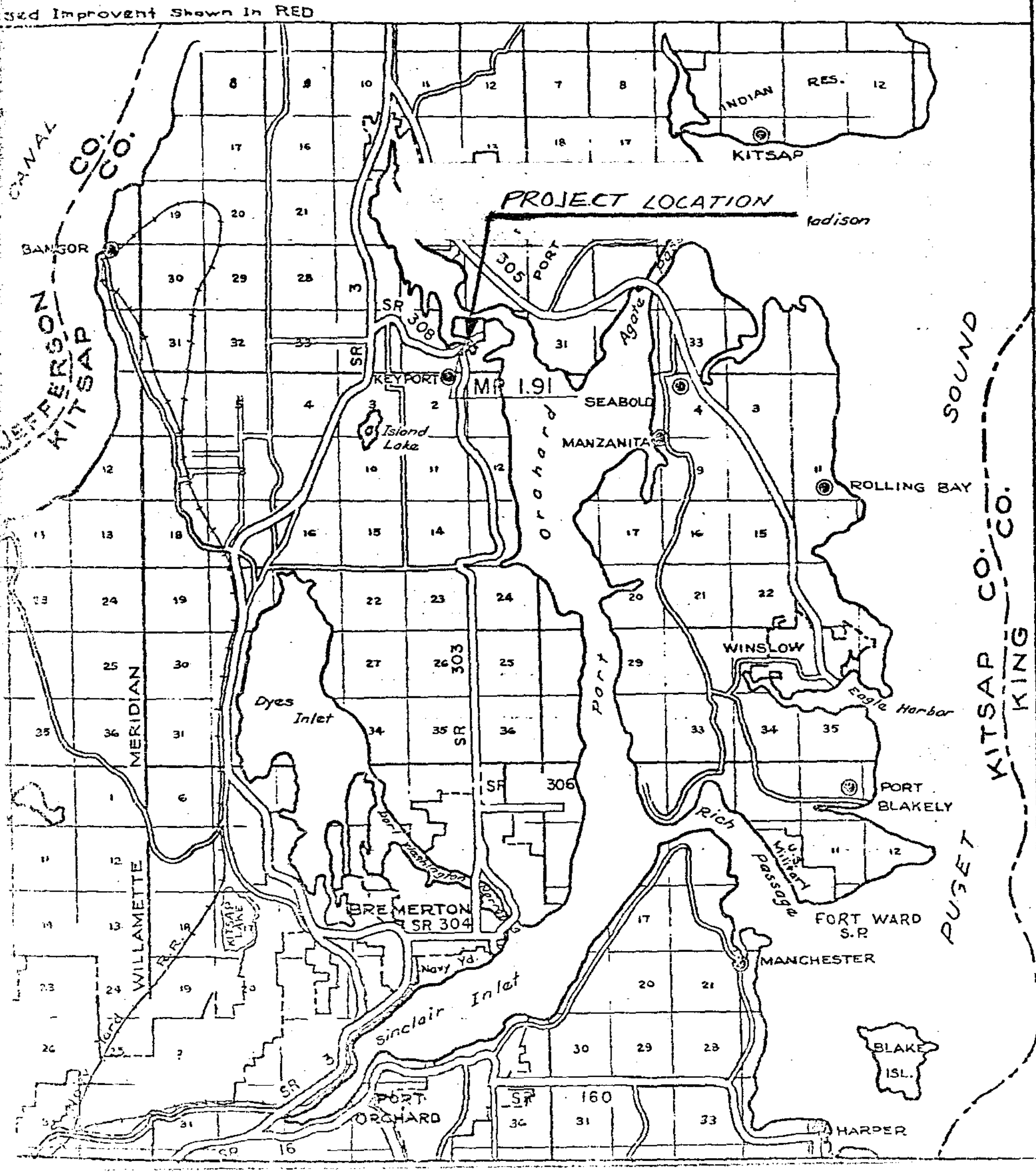
81W017

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

OLYMPIA, WASHINGTON

MAP OF STATE HIGHWAYS

KITSAP COUNTY



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] 1"-1½"	1½"-2"	2"-2½"	Average Half Cell (V)
	Control Pile				
1	Pier 2: 1 foot below cap	7.41	4.20	0.78	-0.242
	within tidal zone	5.71	2.72	1.57	-0.353
	Experimental Piles				
2	Pier 2: 1 foot below cap	5.38	2.97	1.14	-0.224
	within tidal zone	8.42	7.27	4.56	-0.448
3	Pier 3: 1 foot below cap	7.08	4.06	1.61	-0.269
	within tidal zone	5.48	3.38	1.37	-0.421
4	Pier 3: 1 foot below cap	5.12	1.99	0.49	-0.207
	within tidal zone	4.57	3.15	1.19	-0.399
	Deck				
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 threshhold 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

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 Fe_3O_4, to ferric oxide (Fe_2O_3). 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 Fe_2O_3. This layer of Fe_2O_3 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 $CaCl_2$ or even from salt-laden air. The chloride ion penetrates the thin protection layer of Fe_2O_3 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 $Fe(OH)_2$ ($=FeO \cdot H_2O$) and oxidizes to Fe_2O_3. Meanwhile, the chloride ion, which has been freed from the complex by the precipitation, goes back through the Fe_2O_3 layer to cause more corrosion. Eventually, the film of Fe_2O_3 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.)

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:

$Fe^o \longrightarrow 2e + Fe^{++}$

(iron metal) (Electrons) (Ferrous ions)

(These will be picked up by oxygen at the cathode.)

$\downarrow Cl^-$

$[FeCl]^+$

This complex moves through Fe_2O_3 into concrete

$\downarrow OH^-$ (from concrete)

$Fe(OH)2 + Cl^-$

$\downarrow O_2$

Fe_2O_3

(Final corrosion product)

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

$$2Fe^{++} + 2NO^-_2 + H_2O \longrightarrow Fe_2O_3 + 2NO + 2H^+$$

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

Sheet 1 of 2
Date 7/23/31

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

CHANGE ORDER

AUG 06 1981

Change Order Number 2

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

☐ Change proposed by Contractor

Endorsed by: Hurlen Construction Co.
Contractor Firm Name

Signature — 30 July
Date

Title PRESIDENT

Consent given by Surety: (when required)

By: ______ Attorney-in-fact ______ Date

2055

Hurlen Construction Co.
P. O. Box 80945
Seattle, Wa. 98108

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:

Add Darex Corrosion Inhibitor (DCI) to all concrete used in the prestressed concrete piles, excluding the test piles, and in the prestressed 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.

☐ DISTRICT APPROVAL REQUIRED ☐ 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	$ 7625.00	$ 267,835.00

DISTRICT USE

APPROVAL RECOMMENDED

Project Engineer — 7/25/81 Date

☒ APPROVAL RECOMMENDED ☐ APPROVED

DISTRICT ADMINISTRATOR A. R. Morrell

By: R. L. Barclay Date: 8-5-81

HEADQUARTER'S USE

APPROVED:

BK FOR M J Nash Highway Construction Engineer 8/18/81 Date

DOT FORM 421-003 REV. 10/79

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	9.50
Subtotal	$36.50
15% P & OH (Fabricator)	5.48
15% P & OH (Prime)	5.48
	$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

PHONE (AREA CODE 312) SAGINAW 1-2200

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^{0}	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

3 -
WHF:lg

FLOOD TESTING LABORATORIES, INC.

PHONE: (AREA CODE 312) SAGINAW 1-22

1945 EAST 87TH STREET
CHICAGO, ILLINOIS 606

REPORT OF TEST OF

Design OF Concrete Mixture

LABORATORY NO. DATE November 23,1979
Page No. 14

SAMPLED BY:

SAMPLED FROM: AMOUNT

MANUFACTURED BY:

CONTRACTOR: Construction Products Division
W.R. Grace & Company
6051 West 65th Street
Chicago, Illinois 60638
Att: Mr. Leo Rojic

REMARKS:

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

Computed Mix Data	Per Cubic Yard	Per Sack Cement	Absolute Volume Cu.Ft./Cu.Yd.
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 AEA	8.0 fl.oz.	1.5 fl.oz.	
Air, Content Net %	5.5		1.49
Slump, Inches	2 1/2		
Water-Cement Ratio,Gals./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.

RESPECTFULLY SUBMITTED.

FLOOD TESTING LABORATORIES, INC.

WHF:lg

APPENDIX C

Change Order No. 3

Sheet 1 of 3

Date 10/21/81

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

CHANGE ORDER

NOV 12 1981

Change Order Number 3

☒ 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
Contractor Firm Name

Signature: [signature] Date: 28 OCT 81

Title PRESIDENT

Consent given by Surety: (when required)

By: ______ Attorney-in-fact ______ Date

SR 308
Federal Aid No. BRF-308(2)
Project Title 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 ~~cadwell~~ 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.

	ORIGINAL CONTRACT AMOUNT	CURRENT CONTRACT AMOUNT	ESTIMATED NET CHANGE THIS ORDER	ESTIMATED CONTRACT TOTAL AFTER CHANGE
☐ DISTRICT APPROVAL REQUIRED ☒ HEADQUARTERS APPROVAL REQUIRED	$ 256,599.00	$ 267,835.00	$ 971.00	$268,806.00

DISTRICT USE

APPROVAL RECOMMENDED

______ Project Engineer ______ Date

☒ APPROVAL RECOMMENDED ☐ APPROVED

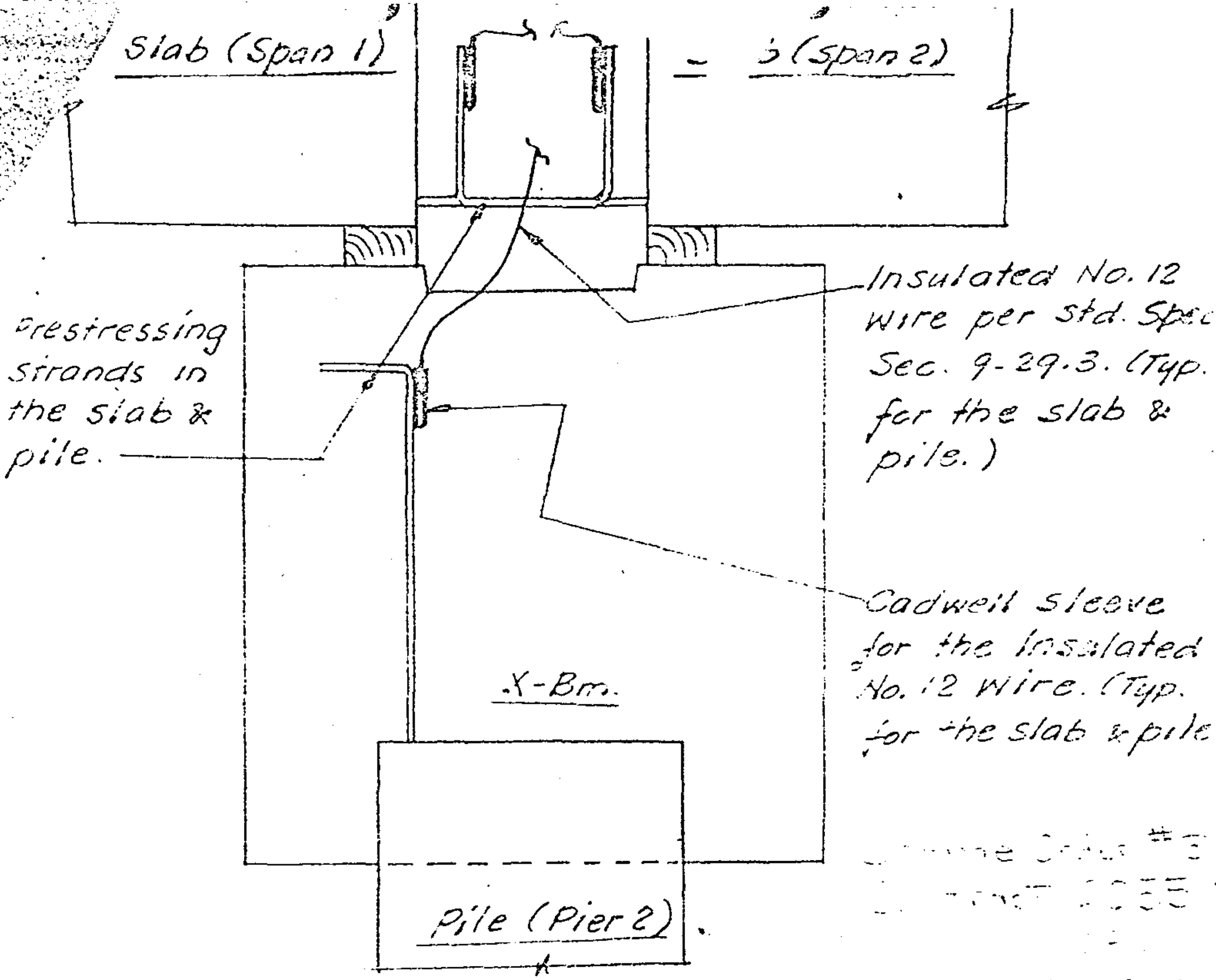
DISTRICT ADMINISTRATOR A. K. Morrell

By: D. L. Barclay Date: 11-10-81

HEADQUARTER'S USE

APPROVED: [signature] 11/12/81
Highway Construction Engineer Date

DOT FORM 421-003
REVISED 9/79



Notes:

1. Install at Pier 2, 2 ~~Cadwell~~ Cadweld sleeve and 2 No. ~~12~~ 8 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

APPENDIX D

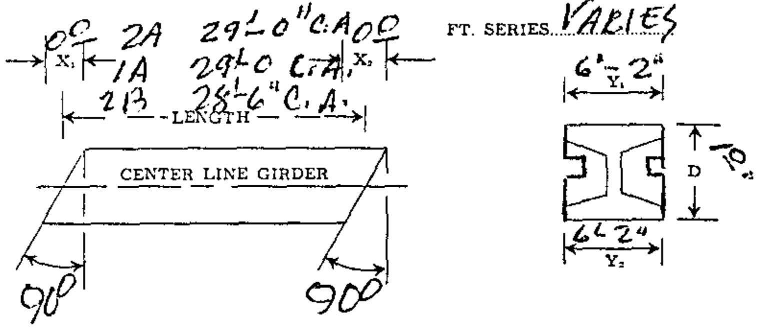
Prestressed Slab Reports

PRESTRESSED CONCRETE GIRDER REPORT NO. 1

CONT. NO. 2055 F. A. NO. BRF-308 (2) HWY. NO. ______ S. R. 308 CONC. MIX 11A AGGREG. SOURCE PIT D47

SECTION DOGFISH Bay BRDGE REPLACEMENT % SAND PASSING #16 64.3 % GRAVEL PASSING ¾" 96.7

BRIDGE NAME DOGFISH CONTR. HURLEN Const Co CEM. BRAND IDEAL TYPE III SKS./C.Y. 7¼ WATER G.P.S. 45



FT. SERIES VARIES

PRETENSION CABLES: Sumiden Wire Products

LOT NO. SEE Remarks REEL NO. BELOW

STRGHT. CABLE NO. 29 SIZE ½ 270K 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 0130

REMARKS 42½ ozs OF D.C.I. IN MIX PER 100 LBS CMT & 40 ozs Pozz 300R/C.Yd

GIRDER NO.	DATE POURED	POUR TIME BEGIN	END	AIR TEMP.	CONC. TEMP.	SLUMP	CURING Hr. Steam	CURING Avg. Temp.	CYL. NO.	DATE TESTED	AGE HRS.	PSI	* Camber	FINISHED LENGTH	REMARKS
2B-1	8-14-81	1015	1045	73°	83°	3¾	12	115°	CTR	8-17-81	68¾	5060	+27/32	28'-6¼	KD216 14224-A V1809
1A-3	8-12-81	1515	1540	87°	82°	3"	10½	148°	CTR	8-13-81	14½	5555	19/32	29'-0⅛	14226C V1813+
2A-2	8-13-81	1400	1430	85°	82°	3¼"	16	153°	CTR	8-17-81	89	5570	+1"	29'-0⅛"	KD 217
1A-2	8-11-81	1545	1615	93°	81°	3¼"	14½	156°	CTR	8-17-81	135¼	5570	+¾	29'-0 3/16	14234A V1815
2A-1	8-11-81	1512	1540	93°	82°	2¾"	14½	149°	CTR	8-12-81	15	5235	+19/32	29'-0⅛	14234C V1817+
1A-1	8-10-81	1330	1405	93°	85°	3½"	12	152°	N S	8-11-81	16¾	5305 5535	+19/32	29'-0⅛	
									AVG			5423			6090

5000 PSI At REL
6000 " At 28 DAY

* Camber at center of girder

REMARKS Made at Assoc. A & I.
C. Emmett

PROJ. ENG'R. HOLGERSON
FIELD INSP. NELSON/SATHER
DATE 8-17-81

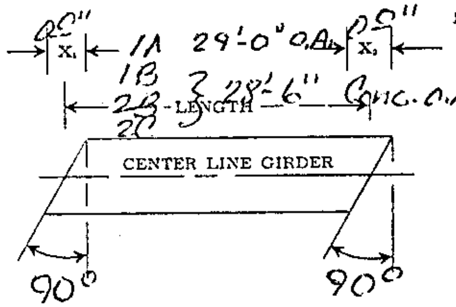
FORM 450-002 (H.F. 23.42)
REVISED 4/72

PRESTRESSED CONCRETE GIRDER REPORT NO. 2

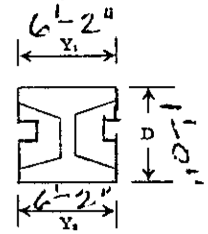
CONT. NO. 7055 F. A. NO. BRF-308 (2) HWY. NO. ____ S. R. 308 CONC. MIX 11A AGGREG. SOURCE PIT D47

SECTION DOGFISH BAY BRIDGE REPLACEMENT % SAND PASSING #16 44 % GRAVEL PASSING 3/4" 98.5

BRIDGE NAME DOGFISH CONTR. HURLEN Const. CEM. BRAND IDEAL TYPE III SKS./C.Y. 7 1/4 WATER G.P.S. 4 5/8+



FT. SERIES VARIES



PRETENSION CABLES: Sumiden Wire Prods Corp

LOT NO. SEE REMARKS REEL NO. BELOW

STRGHT. CABLE NO. 29 SIZE 1/2 270K HRPD. CABLES NO. N SIZE A

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 8-21-81 TIME 0800

REMARKS

GIRDER NO.	DATE POURED	POUR TIME BEGIN	END	AIR TEMP.	CONC. TEMP.	SLUMP	CURING Hr. Steam	Avg. Temp.	CYL. NO.	DATE TESTED	AGE HRS.	PSI	* Camber	FINISHED LENGTH	REMARKS
2C-2	8-20-81	1600	1645	70	75	2 1/2	12	145°	AVG	8-21-81	13 3/4	5430	1 3/32	28' 6"	KC10 13897B V1608
1B-2	8-20-81	1500	1545	70	75	2 1/2	12	140°	AVG	8-21-81	14 3/4	5625	2 1/32	28' 6"	KA119 13926B V1607+
2C-1	8-19-81	3:30 pm	4:00 pm	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	3:00 pm	3:20 pm	77°	78°	3"	12	145°	CTR	8-20-81	15 1/4	5675	3/4	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	~~5660~~	17/32	28' 6"	KA155 14006B V1610+
															KD217 14234A V1815+
1A-4	8-18	1255	1315	85°	80°	3"	16	140°	CTR	8-19-81	17 1/2	5375 ~~7070~~	13/32	29' 0"	
															6090

* Camber at center of girder

MAT'LS. LAB. 5000 PSI At REL. 6000 " At 28 day

REMARKS Mark C. Assoc. Eng. M. Co. Emmett

PROJ. ENGR. HALGERSON

FIELD INSP. NELSON/SATHER

DATE 8-21-81

FORM 450-002 (H.F. 23.42) REVISED 4/72

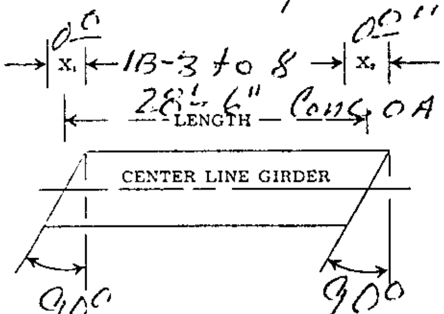
PRESTRESSED CONCRETE GIRDER REPORT NO. 3

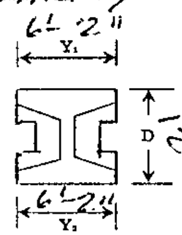
CONT. NO. 2055 F. A. NO BRF-308 (2) HWY. NO. ______ S. R. 308 CONC. MIX 11A AGGREG. SOURCE PIT D47

SECTION DOGFISH BAY BRIDGE REPLACEMENT % SAND PASSING #16 64.3 % GRAVEL PASSING ¾" 97.6

BRIDGE NAME DOGFISH BAY CONTR HURLEN' CONST CO. CEM. BRAND IDEAL TYPE III SKS./C.Y. 7¼ WATER G.P.S. 4.5+

FT. SERIES VARIES





PRETENSION CABLES: SUMIDEN WIRE PRODS CORP

LOT NO. SEE REMARKS REEL NO. BELOW

STRGHT. CABLE NO. 29 SIZE ½" 270K HRPD. CABLES NO. —— SIZE ——

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 0830

REMARKS 12½ ozs OF D.C.I. /CWT IN MIX & 38 ozs POZZ 300R / C. Yd.

GIRDER NO.	DATE POURED	POUR TIME BEGIN	END	AIR TEMP.	CONC. TEMP.	SLUMP	CURING Hr. Steam	Avg. Temp.	CYL. NO.	DATE TESTED	AGE HRS.	PSI	* Camber	FINISHED LENGTH	REMARKS
IB-3	8-25-81	1025	1050	66°	77°	2 7/8	11	100°	CTR	8-26-81	19¾	5660	5/16"	28'-5 5/8"	KD 217 14234B-V1816
IB-4	8-25-81	1105	1135	71°	77°	3¼	8	102°	CTR	8-26-81	19¼	5090	7/16	28'-5¾"	KD 324 14931-V2001
IB-5	8-26-81	1500	1520	80°	79°	3"	5	128°	CTR	8-31-81	110¾	6065	21/32	28'-5¾	14932-V2002
IB-6	8-26-81	1650	1707	72°	77°	2 7/8	6	127°	CTR	8-27-81	13	5555	½"	28'-5 5/8	14933-V2003
IB-7	8-27-81	1425	1450	73°	77°	3½	8	117°	CTR	8-31-81	87¾	5605	21/32	28'-6"	14936-V2001
															KD 119 13941B-V1605+
IB-8	8-28-81	0900	0925	68°	75°	3"	4	131°	CTR	8-31-81	69¼	6120	5/8"	28'-5½"	

5000 PSI AT REL.
6000 PSI AT 28 DAY

REMARKS Made @ Assoc. A.&.S.
C. Everett

* Camber at center of girder

PROJ. ENG'R Hallgerson
FIELD INSP. Nelson / Sather
DATE 8-31-81

FORM 450-002 (M.F. 23.42) REVISED 4/72

APPENDIX E

Prestressed Pile Reports

PRESTRESS PILE RECORD

Highway No. 308 Section DOGFISH BAY BRIDGE REPLACEMENT 308/157

Contract No. 2055 Report No. 6 Outside Diameter 16½" Wall Thickness N/A

Pre-Tension Cables: Lot No. BELOW Reel No. BELOW Straight Cables: No. 15 Size ½" Ø 270 K

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					
5P21	31'0"	8-19-81	140 PM	225 PM	77	78	3"	130°	39½		N	8-21-81	6870	8-21-81 0800	31'0"
P22	"							"	"		S	"	7305		"
23	"							"	"		AVG	"	7088		"
24	"							"	"						"
5P25	"							"	"						"

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

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

NELSON/SATHER 8-21-81
Field Inspector

I.F. 26.73 (Rev.)

PRESTRESS PILE RECORD

Highway No. 308 Section DOGFISH BAY BRIDGE REPLACEMENT 308/151

Contract No. 2055 Report No. 5 Outside Diameter 16½" Wall Thickness N/A

Pre-Tension Cables: Lot No. BELOW Reel No. BELOW Straight Cables: No. 15 Size ½" 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 Steam	Hrs. of Cure Water	Cyl. Nos.	Date Broke	P. S. I.	Destress Date/Time	Finished Length
4P-16	31'-0"	8-17-81	1400	1450	81°	80°	2¾				S	8-18-81	6030	8-19-81 0815	31'-0½
4P-17	31'-0"	"	"	"	"	"	"								31'-0¼
4P-18	31'-0"	"	"	"	"	"	"								31'-0¼
4P-19	31'-0"	"	"	"	"	"	"				N	8-18-81	5625		31'-0¼
4P-20	31'-0"	"	"	"	"	"	"					AVG	5528		31'-0¼

Remarks: KA119-13926B-V1607, 13942B-V1606 KA155-14006B-V1610
KA010-13897B V1608 38 ozs Pozz 300R/C.Yd & 42½ Ozs
DCI PER 100# Cwt MADE At ASSOC. S&G. Co. EVERETT

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

5500 PSI At REL.
7000 " At 28day

NELSON / SATHER 8-19
Field Inspector Date

D.I.F. 26.73 (Rev.)

PRESTRESS PILE RECORD

Highway No. 308 Section DOGFISH BAY BRDGE REPLACEMENT 308/151

Contract No. 2055 Report No. 4 Outside Diameter 16½" Wall Thickness N/A

Pre-Tension Cables: Lot No. BELOW Reel No. BELOW Straight Cables: No. 15 Size ½ 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 Steam	Hrs. of Cure Water	Cyl. Nos.	Date Broke	P. S. I.	Destress Date/Time	Finished Length
3P-11	31'-0"	8-15-81	1030	1110	65°	80°	2 7/8	28	16°		N	8-17-81	N 6420	8-17-81 8:00AM	31'-0¼"
3P-12	31'-0"	"	"	"	"	"	"					"	S 6470	"	31'-0¼"
3P-13	31'-0"	"	"	"	"	"	"					"	AVG. 6445	"	31'-0¼"
3P-14	31'-0"	"	"	"	"	"	"					"	"	"	31'-0¼"
3P-15	31'-0"	"	"	"	"	"	"	26	14°		S	"	"	"	31'-0¼"

Remarks: KA 119 - 13926 B - V1607 - 13942 - V 1606, KA155 - 14006 B - V1610 KA010 - 13897 B V1608 - 38 cyd Pozz 300R/Cyd & 42½ OZS DCI PER 100# CWT. 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

8-17-81 — Date

D.I.F. 26.73 (Rev.)

PRESTRESS PILE RECORD #3

Highway No. 308 Section DOGFISH BAY BRDGE REPLACEMENT

Contract No. 2055 Report No. 2 Outside Diameter 16½" Wall Thickness N/A

Pre-Tension Cables: Lot No. BELOW Reel No. BELOW Straight Cables: No. 15 Size ½ 4 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: Steam	Hrs. of Cure: Water	Cyl. Nos.	Date Broke	P. S. I.	Destress Date/Time	Finished Length
2P-6	31'0"	8-13-81	1535	1610	86	84	2½	135°	34		3	8-15-81 [illegible]	5555	8-15-81 0645	31'-0¼
2-7	31'0"	"	"	"	"	"	"					8-15-81			"
2P8	31'0"	"	"	"	"	"	"								"
2P9	31'0"	"	"	"	"	"	"								"
2P10	31'0"	"	"	"	"	"	"	120°	34				5640		"
												AVG	5598		

Remarks: KD216 - 14225C - V1811 & KD 217 - 14234B V1816 - Sumi
USIN D.C.I. IN MIX 42½ ozs/100# CWT & 40 ozs 700K / C.Yd
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. Melsey & Sattler — Field Inspector — 8-15-8_ Date

D.I.F. 26.73 (Rev.)

PRESTRESS PILE RECORD

Highway No. 308 Section DOGFISH BAY BRIDGE REPLACEMENT

Contract No. 2055 Report No. 2 Outside Diameter 16 1/2" Wall Thickness

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 Steam	Hrs. of Cure Water	Cyl. Nos.	Date Broke	P.S.I.	Destress Date/Time	Finished Length
P1-1	31'-0"	8-11-81	1450	1050	80°	54°	3 3/4"	12	139		N	8-13-81	5500	8-13-81 0845	31'-0 1/4
P1-2	31'-0"	"	"	"	"	"	"	"	"					"	"
P1-3	31'-0"	"	"	"	"	"	"	"	"					"	"
P1-4	31'-0"	"	"	"	"	"	"	12	145°					"	"
P1-5	31'-0"	"	"	"	"	"	"	"	"		S	8-13-81	5500	"	"
												AVG	5500	"	"

Remarks: KD 216 Coil 14225C V1811 KD 155 Coil 14006B V1610
USING DCI IN MIX 42 1/2 ozs/CWT & 40 ozs 300R/C.Yd
MADE AT ASSOC S&G Co EVERETT

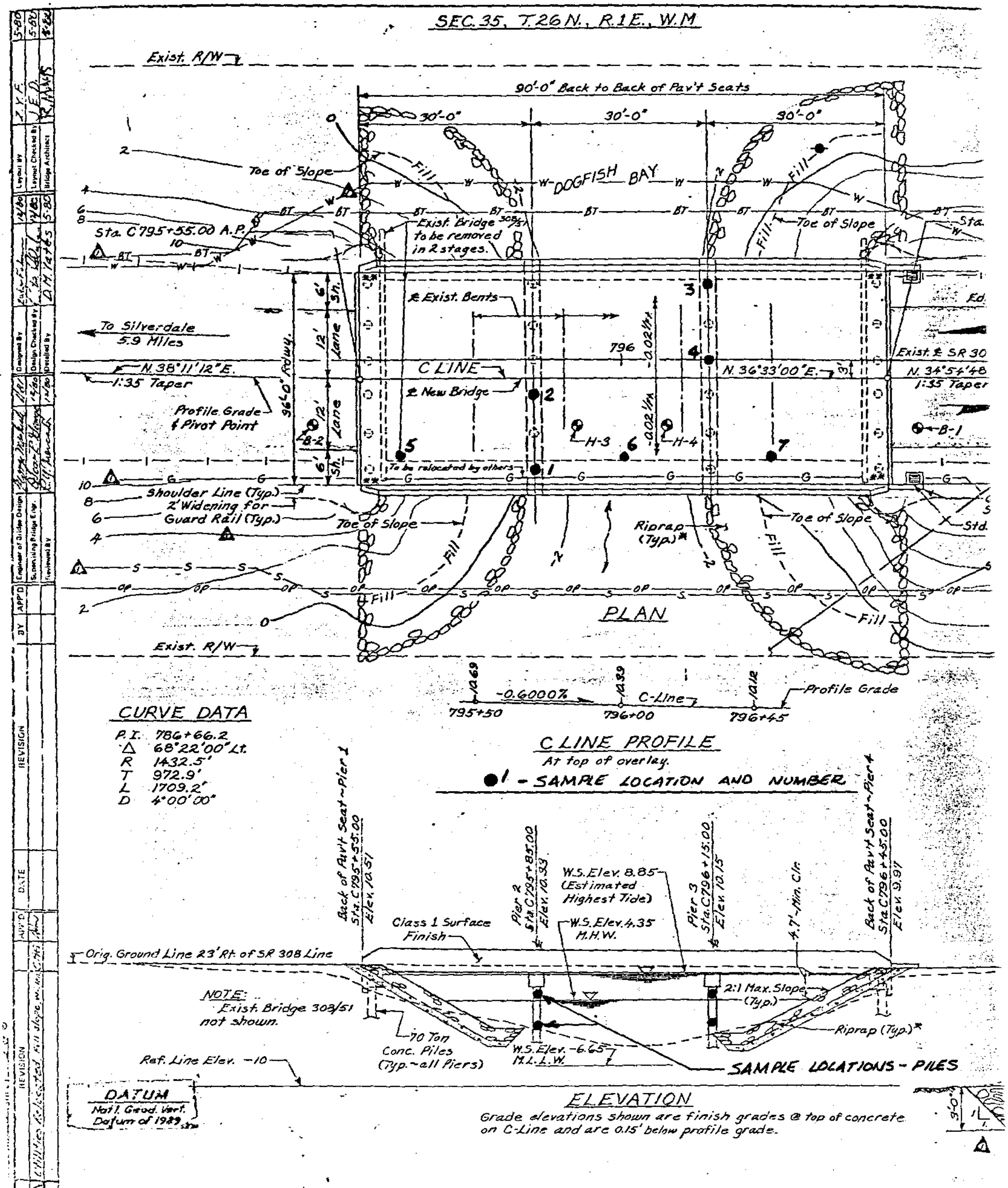
DIST: Bridge Engineer
County Engineer
Materials
District Engineer
Res/Proj Engineer
Field Inspector

5500 PSI AT REL
7000 " @ 28 DAY

NELSON/SATHER 8-13-81
Field Inspector Date

APPENDIX F

Bridge Layout


SEC. 35, T.26N., R.1E., W.M.
Exist. R/W
90'-0" Back to Back of Pav't Seats
30'-0"
30'-0"
30'-0"
Toe of Slope
Fill
DOGFISH BAY
Sta. C795+55.00 A.P.
Exist. Bridge 308/51 to be removed in 2 stages.
Toe of Slope
Exist. Bents
To Silverdale 5.9 Miles
N.38°11'12"E.
1:35 Taper
C LINE
New Bridge
N. 36°33'00"E.
Exist. SR 308
N. 34°54'48"
1:35 Taper
96'-0" Rdwy.
6' Sh.
12' Lane
12' Lane
6' Sh.
796
-0.02'/ft.
-0.02'/ft.
Profile Grade & Pivot Point
B-2
H-3
H-4
B-1
To be relocated by others
Shoulder Line (Typ.)
2' Widening for Guard Rail (Typ.)
Toe of Slope
Riprap (Typ.)*
Toe of Slope
PLAN
Exist. R/W
10.69
10.39
10.12
-0.6000%
C-Line
Profile Grade
795+50
796+00
796+45
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"
C LINE PROFILE
At top of overlay.
● 1 - SAMPLE LOCATION AND NUMBER
Back of Pav't Seat ~ Pier 1 Sta. C795+55.00 Elev. 10.51
Pier 2 Sta. C795+85.00 Elev. 10.33
W.S. Elev. 8.85 (Estimated Highest Tide)
Pier 3 Sta. C796+15.00 Elev. 10.15
4.7' Min. Clr.
Back of Pav't Seat ~ Pier 4 Sta. C796+45.00 Elev. 9.97
Class 1 Surface Finish
W.S. Elev. 4.35 M.H.W.
Orig. Ground Line 23' Rt. of SR 308 Line
2:1 Max. Slope (Typ.)
NOTE: Exist. Bridge 308/51 not shown.
70 Ton Conc. Piles (Typ. ~ all Piers)
W.S. Elev. -6.65 M.L.L.W.
Riprap (Typ.)*
SAMPLE LOCATIONS - PILES
Ref. Line Elev. -10
DATUM
Nat'l. Geod. Vert. Datum of 1929
ELEVATION
Grade elevations shown are finish grades @ top of concrete on C-Line and are 0.15' below profile grade.