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
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 16-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.
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.
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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.

<table>
<thead>
<tr>
<th>No.</th>
<th>Sample Location</th>
<th>Chloride Content (lb/CY)(A)</th>
<th>Average Half Cell (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1&quot;-1½&quot;</td>
<td>1½&quot;-2&quot;</td>
</tr>
<tr>
<td>Control Pile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Pier 2: 1 foot below cap</td>
<td>7.41</td>
<td>4.20</td>
</tr>
<tr>
<td></td>
<td>within tidal zone</td>
<td>5.71</td>
<td>2.72</td>
</tr>
<tr>
<td>Experimental Piles</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Pier 2: 1 foot below cap</td>
<td>5.38</td>
<td>2.97</td>
</tr>
<tr>
<td></td>
<td>within tidal zone</td>
<td>8.42</td>
<td>7.27</td>
</tr>
<tr>
<td>3</td>
<td>Pier 3: 1 foot below cap</td>
<td>7.08</td>
<td>4.06</td>
</tr>
<tr>
<td></td>
<td>within tidal zone</td>
<td>5.48</td>
<td>3.38</td>
</tr>
<tr>
<td>4</td>
<td>Pier 3: 1 foot below cap</td>
<td>5.12</td>
<td>1.99</td>
</tr>
<tr>
<td></td>
<td>within tidal zone</td>
<td>4.57</td>
<td>3.15</td>
</tr>
<tr>
<td>Deck</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Sta. 0+16 27.8 feet right</td>
<td>0.27</td>
<td>0.21</td>
</tr>
<tr>
<td>6</td>
<td>Sta. 0+45 28.2 feet right</td>
<td>0.44</td>
<td>0.33</td>
</tr>
<tr>
<td>7</td>
<td>Sta. 0+70 28.3 feet right</td>
<td>0.29</td>
<td>0.78</td>
</tr>
</tbody>
</table>

(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.

-4-
REFERENCES


APPENDIX A

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 (Fe²⁺) 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.)
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:

\[
\begin{align*}
\text{Fe}^0 & \xrightarrow{2e^-} \text{Fe}^{++} \\
(\text{iron metal}) & \quad (\text{Electrons}) & \quad (\text{Ferrous ions}) \\
& \quad (\text{These will be picked up by oxygen at the cathode.}) \\
& \quad \downarrow \text{Cl}^- \xrightarrow{\text{FeCl}^+} \\
& \quad \text{This complex moves through Fe}_2\text{O}_3 \text{ into concrete} \\
& \quad \downarrow \text{OH}^- \text{ (from concrete)} \\
& \quad \text{Fe(OH)}_2 + \text{Cl}^- \xrightarrow{O_2} \\
& \quad \text{Fe}_2\text{O}_3 \\
& \quad \text{(Final corrosion product)}
\end{align*}
\]

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:

\[
2\text{Fe}^{++} + 2\text{NO}_2^- + \text{H}_2\text{O} \rightarrow \text{Fe}_2\text{O}_3 + 2\text{NO} + 2\text{H}^+
\]

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
CHANGE ORDER

Caused by Engineer under terms of Section 1.04.4 of the Standard Specifications

Change proposed by Contractor:

Issued by: Hurlen Construction Co.
Construction Firm Name

Julie
Signature

The Description of Work is hereby continued (when required)

By: Attorney/inspecting

DATE: 7/22/81

2055

Hurlen Construction Co.
P. O. Box 50945
Seattle, Wa. 98108

SR 308
ERF 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 Darox 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 "Darox 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.

<table>
<thead>
<tr>
<th>DISTRICT APPROVAL</th>
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<th>ESTIMATED NET CHANGE THIS ORDER</th>
<th>ESTIMATED CONTRACT TOTAL AFTER CHANGE</th>
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<tr>
<td>REQUIRED</td>
<td>$ 256,559.00</td>
<td>$ 260,210.00</td>
<td>$ 7625.00</td>
<td>$ 267,635.00</td>
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<td>APPROVAL REQUIRED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DISTRICT USE

APPROVED: 7/25/81

HEADQUARTER'S USE

APPROVED: 9/6/81

A.P. Morrell
Highway Construction Engineer

A.P. Morrell
District Administrator

By: C. C. Healy
Date: 8-5-81
DATE: August 5, 1981

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

TO: T. G. Gray/M. J. Nash

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

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:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Material Cost</td>
<td>$27.00*</td>
</tr>
<tr>
<td>Waste, Testing, Dispenser</td>
<td></td>
</tr>
<tr>
<td>Rental &amp; Setup</td>
<td>9.50</td>
</tr>
<tr>
<td>Subtotal</td>
<td>$36.50</td>
</tr>
<tr>
<td>15% P &amp; OH (Fabricator)</td>
<td>5.48</td>
</tr>
<tr>
<td>15% P &amp; OH (Prime)</td>
<td>5.48</td>
</tr>
<tr>
<td></td>
<td>$47.46/CY of Concrete AX</td>
</tr>
</tbody>
</table>

* 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
Re: Darex Corrosion Inhibitor
ASTM C 494-77a

November 21, 1979

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

WHF: Ig
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
H.R. Grace & Company
6051 West 65th Street
REMARKS: Chicago, Illinois 60638
Att: Mr. Leo Rojic

<table>
<thead>
<tr>
<th>Project:</th>
<th>D.C.I. Test Mix</th>
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</thead>
<tbody>
<tr>
<td>Material:</td>
<td>Coarse Aggregate</td>
</tr>
<tr>
<td>Type:</td>
<td>No.57 Crushed Stone (Regraded)</td>
</tr>
</tbody>
</table>

<table>
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<th>Design Data:</th>
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<tbody>
<tr>
<td>Bulk Specific Gravity(Sat.Surf.Dry)</td>
<td>2.70</td>
</tr>
<tr>
<td>Wt./Cubic Foot, Dry Rodded,lbs.:</td>
<td>96.8</td>
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<td>Voids in Aggregate, %</td>
<td>42.5</td>
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<tr>
<td>Absolute Volume of Coarse Aggregate per Cubic Foot of Mortar</td>
<td>0.64</td>
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<tr>
<td>Absolute Volume of Mortar per Dry Rodded Cubic Foot of Coarse Aggregate</td>
<td>0.89</td>
</tr>
<tr>
<td>Corrections: Coarse Aggregate in Sand, %</td>
<td>0.0</td>
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<tr>
<td>Sand in Coarse Aggregate, %</td>
<td>0.0</td>
</tr>
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<table>
<thead>
<tr>
<th>Computed Mix Data</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Per Cubic Yard</td>
<td>Per Sack Cement</td>
</tr>
<tr>
<td>Sacks of Cement</td>
<td>5.50</td>
</tr>
<tr>
<td>Brand of Cement</td>
<td>See Note</td>
</tr>
<tr>
<td>Weights(Sat.Surf.Dry),lbs.:</td>
<td></td>
</tr>
<tr>
<td>Cement</td>
<td>517</td>
</tr>
<tr>
<td>Sand (Regraded)</td>
<td>1350</td>
</tr>
<tr>
<td>No. 57 Crushed Stone(Regraded)</td>
<td>1782</td>
</tr>
<tr>
<td>Total Water</td>
<td>235</td>
</tr>
<tr>
<td>Admixture: Darex Corrosion Inhibitor</td>
<td>3.45 gallons* 0.627 gallons</td>
</tr>
<tr>
<td>Darex AEA</td>
<td>8.0 fl.oz.</td>
</tr>
<tr>
<td>Air, Content Net %</td>
<td>5.5</td>
</tr>
<tr>
<td>Slump, Inches</td>
<td>2 1/2</td>
</tr>
<tr>
<td>Water-Cement Ratio,Cals./Sack:</td>
<td>5.67x</td>
</tr>
<tr>
<td>Yield: Cu.Ft./Volume of Cement</td>
<td>27.00</td>
</tr>
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<td>Wt./Cubic Foot of Concrete,lbs.:</td>
<td>165.2</td>
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<tr>
<td>Dry Rodded Cubic Feet of Coarse Aggregate</td>
<td>0.682</td>
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</tbody>
</table>

Note: Cement was blend of equal parts by weight of Universal Type I, Penn-Mix Type I, and Marquette Type I.

* 3.45 gallons of D.C.I. contains 12.07 lbs. of solids and 25.12 lbs. of water.

Water in D.C.I. solution used to determine water-cement ratio.

Respectfully Submitted,

FLOOD TESTING LABORATORIES, INC.
APPENDIX C

Change Order No. 3
WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

CHANGE ORDER

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

☐ Change proposed by Contractor

Endorsed by: Hurlen Construction Company

P. O. Box 80945
Seattle, Washington 98108

Title: PRESIDENT
Date: 25 OCT 81

Contract No. 2055

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

SR 308
ERF-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 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.

<table>
<thead>
<tr>
<th>DISTRICT APPROVAL</th>
<th>ORIGINAL CONTRACT AMOUNT</th>
<th>CURRENT CONTRACT AMOUNT</th>
<th>ESTIMATED NET CHANGE</th>
<th>ESTIMATED CONTRACT TOTAL AFTER CHANGE</th>
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<td>APPROVAL REQUIRED</td>
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<tr>
<td>HEADQUARTER'S USE</td>
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<td></td>
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<td></td>
</tr>
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</table>

District Use

Project Engineer
Date: 11-10-81

Highway Construction Inspector

District Administrator

Date: 11-10-51
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.
APPENDIX D

Prestressed Slab Reports
### Prestressed Concrete Girder Report

**Cont. No.** 2055  
**F.A. No.** BRE-308  
**Hwy. No.**  308  
**S.R.** 308  
**Conc. Mix** 11A  
**Aggreg. Source** TAYDUL

**Section** DOGFISH BAY BRIDGE REPLACEMENT  
**% Sand Passing #18** 64.3%  
**% Gravel Passing #4** 96.2%  
**Bridge Name** DOGFISH  
**Constr.** HURLEIN CONSTRUCTION  
**Cem. Brand** IDEAL  
**Type** III  
**SkS/CV** 71/4  
**Water G.P.S.** .45  
**Supplied Wire Products**

<table>
<thead>
<tr>
<th>PT. Series</th>
<th>Values</th>
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<tbody>
<tr>
<td>2A</td>
<td>29.0&quot; 0.000</td>
</tr>
<tr>
<td>1A</td>
<td>28.4&quot; 0.000</td>
</tr>
<tr>
<td>1B</td>
<td>28.6&quot; 0.000</td>
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**Center Line Girder**

<table>
<thead>
<tr>
<th>Girder No.</th>
<th>Date Poured</th>
<th>Four Time Begin</th>
<th>End</th>
<th>Air Temp</th>
<th>Conc. Temp</th>
<th>Slump</th>
<th>Curing</th>
<th>Hr. Stream</th>
<th>Ave. Temp</th>
<th>Cyl. No.</th>
<th>Date Tested</th>
<th>Age Hrs</th>
<th>PSI</th>
<th>Camber</th>
<th>Finished Length</th>
<th>Remarks</th>
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<td>6/14/81</td>
<td>10/15</td>
<td>10/15</td>
<td>73°</td>
<td>82°</td>
<td>34&quot;</td>
<td>12</td>
<td>115°</td>
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<td>8/17/81</td>
<td>16/200</td>
<td>5060</td>
<td>127/42</td>
<td>38/04</td>
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<td>15/15</td>
<td>15/15</td>
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<td>14/00</td>
<td>14/30</td>
<td>85°</td>
<td>34&quot;/4&quot;</td>
<td>16</td>
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<td>C7C</td>
<td>8/17/81</td>
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<td>+1&quot;</td>
<td>0/18&quot; KD 717</td>
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<td>14/2/150°</td>
<td>14/2 149°</td>
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<td>8/17/81</td>
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**Remarks** 40% of D.E. I. Mix Rec 100 LBS C7C 4.40 0.05 82/0 300E 1/0.90

**Pre-Tension Release Date** 8/17/81  
**Time** 01:15

**Remarks** 40% of D.E. I. Mix Rec 100 LBS C7C 4.40 0.05 82/0 300E 1/0.90

**Mix Design** A-14  28 Day  
**Camber at center of girder**

**Dates**
- 6/30/81 A + Rel.  
- 6/30/81 A + 28 Day  

**Signed** W. CORNELIUS

**Field Inspectors**  
- WHEELER  
- NELSOV

**Date** 8/17/81
**Prestressed Concrete Girder Report No. 2**

**Cont. No.** 7456  
**F. A. No.** BRE-308-C2  
**Hwy. No.** S.R. 308  
**S.R. No.** 308  
**Conc. Mix.** N/A  
**Aggreg. Source** PTDU-7

**Section:** Dogfish Bay Bridge Replacement  
**Concrete:** CEM. BRAND: IDEAL  
**Type:** III  
**Sk/S/C Yr 744**  
**Water G.P.S.** 6.8

** Pretension Cables:** Sumiden Wire, Prods Corp

<table>
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<tr>
<th>Girder No.</th>
<th>Date Poured</th>
<th>Pour Time Begin</th>
<th>End</th>
<th>Air Temp</th>
<th>Conc. Temp</th>
<th>Slump</th>
<th>Curing</th>
<th>Cyclo.</th>
<th>Date Tested</th>
<th>Age Hrs.</th>
<th>PSI</th>
<th>Camber</th>
<th>Finished Length</th>
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<td>1600</td>
<td>1645</td>
<td>70</td>
<td>75</td>
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<td>12</td>
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<td>12</td>
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<tr>
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<td>3:30 PM</td>
<td>3:30pm</td>
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<td>1620</td>
<td>90°</td>
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<td>8-21-81</td>
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<td>1722</td>
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<td>120</td>
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</table>

**Remarks:**  
Marble Creek, Ohio  
Date: 6-20-81

**𝖍𝖆𝖇𝗶𝖑𝖎𝖓𝖌**  
**Proj. Engnr.:**  
**Field Insp.:**  
**Date:** 6-20-81

---

*Camber: at center of girder

**(Maps Lab. 6000 psi at 28 days)  
**Rece. Notes: **Marble Creek, Ohio  
**Date:** 6-20-81

---

**Form 1128-3 (10-75)  
Revised 4/72**
Prestressed Concrete Girder Report No. 3

CONT. NO. 2455  F.A. NO.BRF-38 (2)  HWY. NO. S.R. 388  CONC. MIX 1/1  AGGREG. SOURCE PT D47

SECTION DOG FISH BAY BRIDGE REPLACEMENT  % SAND PASSING #18  64.3  % GRAVEL PASSING #4  97.2

BRIDGE NAME DOG FISH BAY  CONTRIBUTION 10.76  CEM. BRAND IDEAL  TYPE III  SKS/CY. 7/4  WATER G.P.S. 4.5+

PRETENSION CABLES  SUNXDEN WIRE PRODS, AIP  LOT NO. SEE REMARKS  REEL NO. BELOW

STREET CABLE NO. 29  SIZE 3/8  HRPD. CABLES NO. SIZE

STRENGTH JACK FORCE  28,900 LBS/CABLE  8,388 LBS  LBS. TOTAL  36,288 LBS.

ELONGATION CALCULATED  29.31"  MEASURED  22.38"

HRPD. JACK FORCE  LBS/CABLE  LBS TOTAL

ELONGATION CALCULATED  MEASURED

PRE-TENSION RELEASE DATE  5-31-81

TIME  0540

REMARKS: 4 1/2 OGF OF D.E.I. 1/4" IN MIX 6.38 353 322 300 1/4. 9/3.01

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<th>GIRDER NO.</th>
<th>DATE Poured</th>
<th>FOUR TIME BEGIN</th>
<th>END</th>
<th>AIR TEMP</th>
<th>CONC. TEMP</th>
<th>SLUMP</th>
<th>CURING</th>
<th>CYL. NO.</th>
<th>DATE TESTED</th>
<th>AGE HRS.</th>
<th>PSI</th>
<th>CAMBER</th>
<th>FINISHED LENGTH</th>
<th>REMARKS</th>
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<td>197</td>
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<td>125°</td>
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<td>17:07</td>
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<td>197</td>
<td>569</td>
<td>7/6 25-81 A1947</td>
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<td>14:50</td>
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5000 PSI AT REL.
GOOG PSI AT UF DAY

REMARKS: [signature]

PROJ. ENG: [signature]
FIELD INS: [signature] SATHER

DATE: 5-31-81
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: 16.5”  Wall Thickness: N/A

Pre-Tension Cables: Lot No. BELOW  Reel No. BELOW  Straight Cables: No. 15  Size: 

Elongation: Calculated: 15”  Measured: 15”  Straight Jacking Force: 2,890 Lbs./Cable 433,500 Total Lbs.

<table>
<thead>
<tr>
<th>Pile Number</th>
<th>Cost Length</th>
<th>Date Pour</th>
<th>Begin Pour</th>
<th>End Pour</th>
<th>Air Temp</th>
<th>Conc. Temp.</th>
<th>Stump (in.)</th>
<th>Avg. Temp</th>
<th>Cureng</th>
<th>Hrs. of Cure</th>
<th>P.S.I.</th>
<th>Date Broke</th>
<th>Date/Time</th>
<th>Finished Length</th>
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</thead>
<tbody>
<tr>
<td>5 P 21</td>
<td>31’0”</td>
<td>8/12/81</td>
<td>140’0”</td>
<td>225’6”</td>
<td>79</td>
<td>78’3” 130</td>
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<td>N</td>
<td>8-21-81</td>
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<td>31’0”</td>
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</tbody>
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Remarks: HEAT# KD 119  COIL 1  13941 B  V1605

KD 217  14234 B  V1810


Dist: Bridge Engineer
County Engineer
Materials Engineer
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.** 2005  
**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"  
**Elongation:** Calculated: 15"  
**Measured:** 15"  
**Straight Jacking Force:** 28,000 Lbs./Cable  
**Total Lbs.** 483,500

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<td>8-18-81</td>
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**Remarks:**

KA119 - 139 26 B V1607 13942 B V1606 KA155 - 14106 B V1610
KA C10 - 138 77 B V1608 380 00 250 300 16 1/2 075
D.C.I PER 100 FT CUB MADE AT ASSN. S.S.C. Co. EVERETT

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

5500 PSI AT REL.  
7000 PSI AT 28 day  
Nelson/Gather 5-19

Field Inspector

D.F. 26.7 (Rev.)
## PRESTRESS PILE RECORD

Highway No. 308  Section: DOGFISH BAY BRIDGE REPLACEMENT  308/151
Contract No. 2055  Report No. 4  Outside Diameter 14.75"  Wall Thickness N/A
Pre-Tension Cables: Lot No. BELOW  Reel No. BELOW  Straight Cables: No. 15  Size: 14.74 x 270K
Elongation: Calculated 15"  Measured 15"  Straight Jacking Force 28,900 Lbs./Cable 153,500 Total Lbs.

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<th>Pile Number</th>
<th>Cast Length</th>
<th>Date Pour</th>
<th>Begin Pour</th>
<th>End Pour</th>
<th>Air Temp.</th>
<th>Conc. Temp.</th>
<th>Stump (in.)</th>
<th>Avg. Temp. Curing</th>
<th>Hrs. of Cure</th>
<th>Cyl. No.</th>
<th>Date Broke</th>
<th>P.S.I.</th>
<th>Destress Date/Time</th>
<th>Finished Length</th>
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<td>8-17-81</td>
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<td>4140</td>
<td>8-17-81</td>
<td>8:00 AM 31'-0&quot;</td>
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Remarks: KA 119 - 1392 16 - V1607 - 13942 - V1607  KA 155 - 14006 13 - V1610
KA 010 - 13897 16  V1606  - 3844 33300R  0.94 6 93% 0ES DCI
PER 100# CMT. MADE AT ASSOC. & 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  8-17-81
Field Inspector  Date
## Prestress Pile Record

**Highway No.** 308  
**Section** Dogfish Bay Bridge Replacement

**Contract No.** 2055  
**Report No.** 2  
**Outside Diameter** 14 1/2"  
**Wall Thickness** N/A

**Pre-Tension Cables:**  
**Lot No.** Below  
**Reel No.** Below  
**Straight Cables:** No. 15  
**Size** 1/2"  
**Elongation:** Calculated 15"  
**Measured** 15"  
**Straight Jacking Force** 2,990 Lbs./Cable  
**Total Lbs.** 459,500

<table>
<thead>
<tr>
<th>Pile Number</th>
<th>Cast Length</th>
<th>Date Pour</th>
<th>Begin Pour</th>
<th>End Pour</th>
<th>Air Temp.</th>
<th>Cone. Temp.</th>
<th>Stump (in.)</th>
<th>Avg. Temp. Curing</th>
<th>Hrs. of Cure</th>
<th>Cyl. Nos.</th>
<th>Date Broke</th>
<th>P. S. I.</th>
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**Remarks:** KD 216 - 142 25°C - V1811 & KD 217 - 142 23°C  
USIN P.C.T. IN MIX 4 1/2" 9 4 1/2" 100% C.M.T. 9 4 1/2 7000 10 8. 4%.  
MADE AT ASSOCI & G. Co.

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

5500 A+ REL.  
7000 PSI AT 28 DAY  
(Includes Shipping)  

W. B. Oelker & Weather 815-8
### Prestress Pile Record

**Highway No.** 308  
**Section** Dog Fish Bay Bridge Replacement  
**Contract No.** 2055  
**Outside Diameter** 16 7/16"  
**Wall Thickness**  
**Pre-Tension Cables: Lot No.** N/A  
**Reel No.** N/A  
**Straight Cables: No.** 15  
**Size**  
**Honingation:** Calculated: 1.5"  
**Measured:** 1.5"  
**Straight Jacking Force:** 24,900 Lbs./Cable  
**Total Lbs.**

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<th>Pile Number</th>
<th>Cast Length</th>
<th>Date Pour</th>
<th>Begin Pour</th>
<th>End Pour</th>
<th>Air Temp.</th>
<th>Core Temp.</th>
<th>Shoot (In.)</th>
<th>Avg. Temp.</th>
<th>Curing</th>
<th>Ht. of Cure</th>
<th>Water</th>
<th>Cyl. No.</th>
<th>Date Broke</th>
<th>P.N.L.</th>
<th>Distress Date/Time</th>
<th>Finished Length</th>
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<td>3-81 5300</td>
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<td>31'-0 1/4&quot;</td>
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**Remarks:** KD 216  
Cyl 142250  
8/18/81  
F155  
Col 142250  
8/18/81  

Using DCA 1A  
Mix 42% 65%  
Cut 2 40% 30%  
Book 10 46  

Made at Asoc & G Co  
Event  

5500 P&I  
A + Rel  

7000 " @ 28 Day  
Nelson/Sather 8-13-81
APPENDIX F

Bridge Layout