EVALUATION OF GRIT-IMPREGNATED, EPOXY COATED PRESTRESSING STRAND ON SOUTH SLOUGH (CHARLESTON) BRIDGE

Bridge No. 1940G

Final Report

Experimental Features Project OR 89-06

by

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prepared for

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16. Abstract

The use of grit-impregnated, epoxy coated prestressing strand is a relatively new design strategy being used for corrosion abatement on new concrete structures. This application was chosen for the South Slough (Charleston) structure because it is subject to a corrosive environment created by the salt in the marine air. Findings from the evaluation of revealed that:

1.) The coated strand was abrasion resistant and that normal handling during fabrication did not damage the coating,

2.) The strands that were monitored did not display significant creep,

3.) Camber measurements appear normal, showing good bonding, and

4.) No cracking of the web or bottom flange was observed.

The use of epoxy coated prestressing strand for beams in aggressive cloride-rich environments is recommended as a "permitted alternative".

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PRESTRESSING, EPOXY COATED, GRIT IMPREGNATED	Available through the Oregon Department of Transportation Research Unit

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

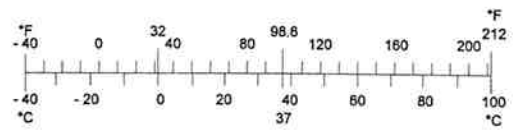
Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

(4-7-94 jbp)

ACKNOWLEDGEMENTS

The author wishes to thank project managers Frank Morrison, Ray Cranston, and their crew for their active role in taking strand and camber measurements. They provided quality information and kept to the time schedule outlined in the workplan. The author would also like to thank Elizabeth Hunt of the Research Unit for reviewing this report.

DISCLAIMER

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EVALUATION OF GRIT-IMPREGNATED, EPOXY COATED PRESTRESSING STRAND ON SOUTH SLOUGH (CHARLESTON) BRIDGE

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1.0 INTRODUCTION

1.1 Background

Oregon's coastal bridges are subject to a corrosive environment because of the salt in the marine air. A significant number of coastal bridges are showing the effects of this harsh environment and will be in need of rehabilitation or replacement over the next several years. If the replacement option is selected, prestressed concrete bridges will most likely be used. In this case, some form of corrosion protection for the pre-stressing steel will be required.

1.2 Objectives

The objective of this study was to evaluate the differences between beams made with a grit-impregnated, epoxy coated, pre-stressing strand and uncoated strand. This was done by performing an inspection during fabrication, monitoring the pre-stressing cables for creep, visually inspecting the beams for cracks and measuring camber.

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2.0 BRIDGE DESCRIPTION

The South Slough Bridge (Bridge No. 1940G) is located on the Cape Arago Highway (Highway 240) in Coos County. The structure, a coastal bridge, is subject to a corrosive environment. A vicinity map showing the project location is in Figure 2.1.

The deck is approximately 1192 feet (360 m) long and has bascule spans near the center to allow ocean vessels passage into the slough. General bridge design drawings are in Appendix A.

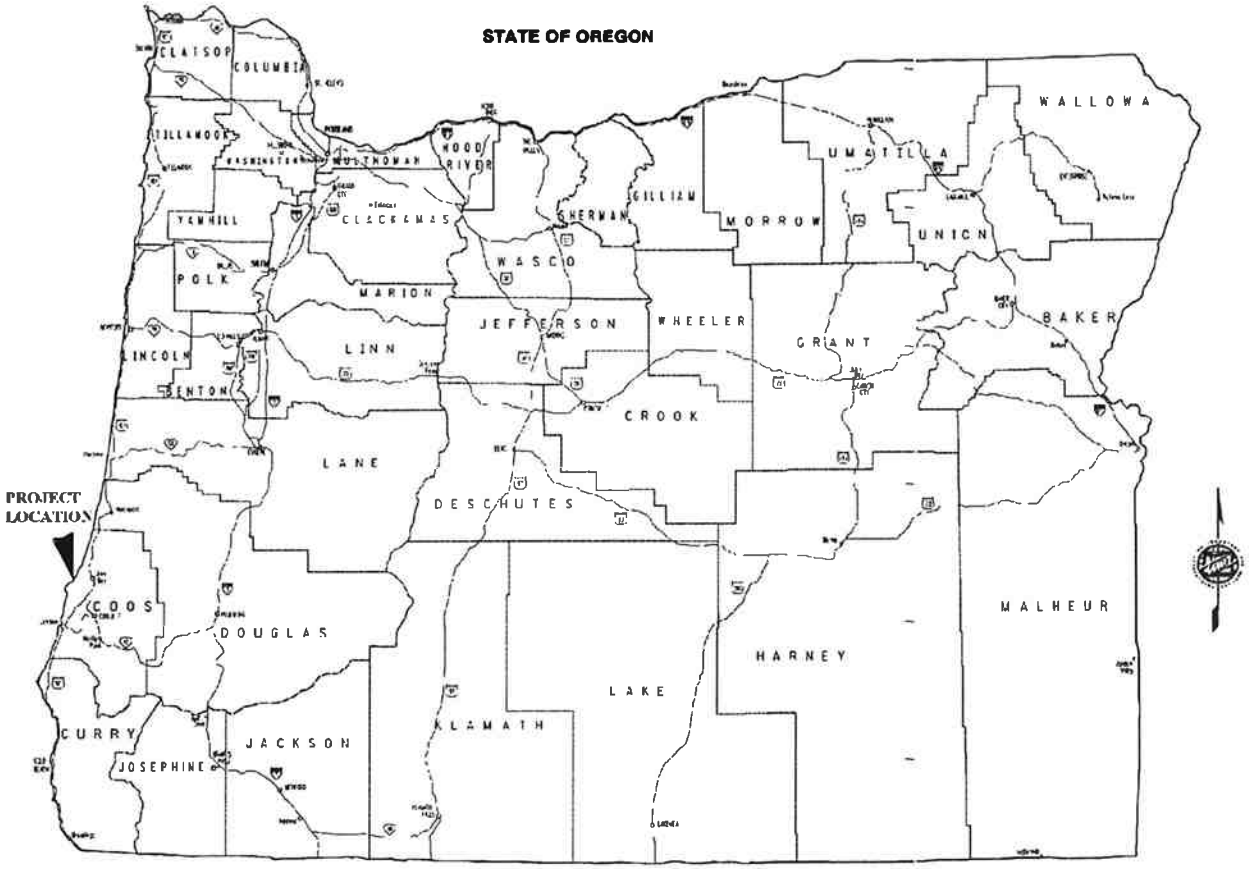

Figure 2.1 Project Location

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3.0 RESULTS

3.1 Fabrication

Handling and stressing characteristics of the strand were observed during fabrication of beam 1-1. The coated strand was found to be abrasion resistant and normal handling during fabrication did not damage the coating (1).

3.2 Strand Measurements

So that strand measurements could be taken from a given reference point throughout the evaluation, reference clamps were mounted on each of two protruding strands. However, these reference points were changed three times because the reference clamps were damaged. When the beam was in place, strand measurements were taken from the beam wall to the tip of strand.

Presented for comparison are three groups of strand measurements. Although comparisons cannot be made between groups, comparisons can be made within each group over the limited time segment.

3.2.1 Group One Strand Measurements:

Group one includes the first set of strand measurements taken shortly after the beam was fabricated and periodically during the next six days. These measurements were taken from the first set of reference clamps (Table 3.1). These show that the epoxy coated strand had a good initial bond with the concrete. The change over time is within the expected tolerances.

Table 3.1: Group One Strand Measurements

	STRAND MEASUREMENTS (IN.)									
DATE	2/15/90		2/16/90		2/16/90		2/19/90		2/20/90	
TIME	8:30 AM		8:00 AM		12:00 NOON		9:00 AM		9:00 AM	
TEMP.	NA		36°F		40°F		29°F		42°F	
	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
	.517	.569	.513	.571	.516	.568	.512	.566	.512	.567
	.518	.570	.513	.571	.515	.569	.515	.569	.513	.568
	.518	.568	.514	.575	.516	.569	.514	.569	.513	.569
	.519	.569	.513	.568	.516	.568	.511	.570	.512	.569
			.513	.571	.515	.568	.513	.569	.513	.567
AVG.	**.518**	**.569**	**.513**	**.571**	**.516**	**.568**	**.513**	**.569**	**.513**	**.568**

3.2.2 Group Two Strand Measurements:

Group two strand measurements were taken periodically while the beam was stored at the casting plant. These measurements were taken from a second set of reference clamps and are shown in Table 3.2. Group two measurements, taken over a ninety day period, do not reveal any significant slippage.

Table 3.2: Group Two Strand Measurements

	STRAND MEASUREMENTS (IN.)					
DATE	3/2/90		3/6/90		5/30/90	
TIME	9:30 AM		10:00 AM		(Shipping Date)	
TEMP	50°F		50°F		NA	
	Top	Bottom	Top	Bottom	Top	Bottom
	.578	.509	.577	.513	.577	.512
	.578	.509	.577	.513		
	.576	.508	.577	.513		
	.579	.510	.578	.513		
	.579	.510	.578	.513		
AVG.	**.578**	**.509**	**.577**	**.513**		

3.2.3 Group Three Strand Measurements:

A third group of strand measurements were taken after the beam was in place. These measurements are of the whole protruding strand length rather than from a reference point and are reported in Table 3.3. These measurements do not show any slippage.

Table 3.3: Group Three Strand Measurements

	STRAND MEASUREMENTS (FT.)			
DATE	7/17/91	1/31/92	10/8/92	6/15/93
TOP STRAND	.84	.83	.84	.84
BOTTOM STRAND	1.51	1.50	1.51	1.50

3.3 Camber Measurements

3.3.1 Camber Measurements Taken at the Casting Plant

Initial camber measurements were taken shortly after release. Additional camber measurements were taken 10 days later and again prior to the beam being shipped to the construction site approximately 100 days later. The results were as follows:

Beam camber at release.(2/15/90) = 1 9/16 inch
After beam was moved to storage.(2/26/90) = 1 13/16 inch
Before shipping to bridge site.(5/30/90) = 2 11/32 inch

3.3.2 Camber Measurements Taken In-Place

Camber measurements were taken from the bottom of the in-place beam, on the dates shown. Camber readings appear normal, showing good bonding. Field survey measurements used to figure camber are in Tables B-1 and B-2 of Appendix B.

Date:	6/28/91	1/13/92	7/28/92	6/15/93
Camber:	1 2/3 inch	1 2/3 inch	1 1/3 inch	1 1/3 inch

3.4 Crack Inspection

The beam at release did not have any visible cracks. Crack inspections were performed by the project manager's crew after construction and no cracking was reported. A final crack inspection was performed on June 15, 1993. Along with beam 1-1, the web and bottom flange of beams 1-2, 1-3, 1-4, 1-5, and 1-6 were also inspected. No cracking was observed.

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4.0 CONCLUSIONS

This is the second evaluation of beams made with grit-impregnated, epoxy coated pre-stressing strand. The first project was the Hubbard Creek Bridge (1,2). Information from both of these projects supports the conclusion that epoxy coated pre-stressing strand does not cause any short term problems with beam performance.

The following conclusions can be made:

1. The use of epoxy coated strands caused no significant construction or casting problems.

2. Cable movement with respect to the concrete was not detectable.

3. The camber before and after erection was very similar to what is expected for beams made with uncoated wire.

4. There was no cracking found in the beams.

5.0 RECOMMENDATIONS

The use of epoxy coated prestressing strand for beams in aggressive chloride-rich environments is recommended as a "permitted alternative".

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6.0 REFERENCES

1. Rusnak, James "Evaluation of Grit-Impregnated Epoxy Coated Prestressing Strand on South Slough (Charleston) Bridge, Bridge No. 1940G", December 1991.

2. Petrak, Allison and Brooks, Eric W.; "Evaluation of Bond-Controlled Epoxy-Coated Prestressing Strand on Hubbard Creek Bridge." October 1990.

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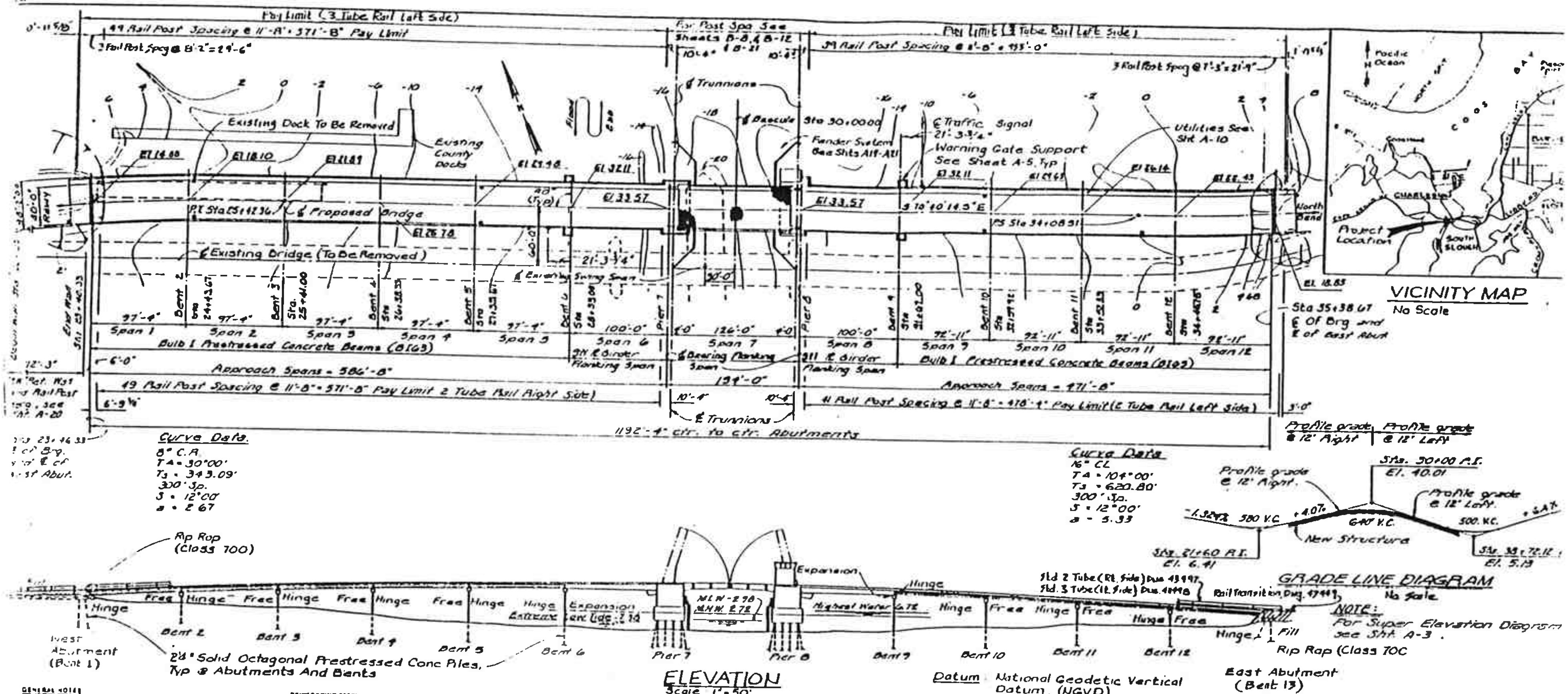
APPENDIX A

PLAN DETAILS


Pay Limit (3 Tube Rail Left Side)
49 Rail Post Spacing @ 11'-8" = 571'-8" Pay Limit
3 Rail Post Spcg @ 8'-2" = 24'-6"
For Post Spa See Sheets B-8, & B-12 & B-21
Pay Limit (3 Tube Rail Left Side)
39 Rail Post Spacing @ 11'-8" = 455'-0"
3 Rail Post Spcg @ 7'-3" = 21'-9"
Existing Dock To Be Removed
Existing County Docks
Trunnions
Bascule Sta 30+00.00
Fender System See Shts A11-A21
Traffic Signal
Warning Gate Support See Sheet A-5, Typ
Utilities See Sht A-10
Proposed Bridge
Existing Bridge (To Be Removed)
Existing Swing Span
North Bend
Span 1
Span 2
Span 3
Span 4
Span 5
Span 6
Span 7
Span 8
Span 9
Span 10
Span 11
Span 12
Bulb I Prestressed Concrete Beams (BI63)
Bulb I Prestressed Concrete Beams (BI63)
Approach Spans = 586'-8"
Approach Spans = 471'-8"
49 Rail Post Spacing @ 11'-8" = 571'-8" Pay Limit 2 Tube Rail Right Side)
41 Rail Post Spacing @ 11'-8" = 478'-4" Pay Limit (2 Tube Rail Left Side)
Trunnions
1192'-4" ctr. to ctr. Abutments
Sta 35+38.67
Of Brg and of East Abut
VICINITY MAP
No Scale
Pacific Ocean
Coos
Charleston
South Slough
Project Location
Curve Data
8° C.A.
T.A = 30°00'
Ts = 343.09'
300' Sp.
S = 12°00'
a = 2.67
Curve Data
16° CL
T.A = 104°00'
Ts = 620.80'
300' Sp.
S = 12°00'
a = 5.33
Profile grade @ 12' Right
Profile grade @ 12' Left
Sta. 30+00 P.I.
El. 40.01
New Structure
Sta. 21+60 P.I.
El. 6.41
Sta. 38+72.12
El. 5.19
Rip Rap (Class 700)
Expansion
Hinge
Free
M.L.W -2.98
M.H.W. 2.72
Highest Water 6.72
Std 2 Tube (Rt. Side) Dwg 43997
Std. 3 Tube (Lt. Side) Dwg. 41998
Rail Transition Dwg. 47443
GRADE LINE DIAGRAM
No Scale
NOTE:
For Super Elevation Diagram see Sht. A-3.
West Abutment (Bent 1)
Bent 2
Bent 3
Bent 4
Bent 5
Bent 6
Pier 7
Pier 8
Bent 9
Bent 10
Bent 11
Bent 12
24" Solid Octagonal Prestressed Conc Piles, Typ @ Abutments And Bents
Rip Rap (Class 700)
East Abutment (Bent 13)
ELEVATION
Scale 1" = 50'
Datum: National Geodetic Vertical Datum (NGVD)

GENERAL NOTES

ALL MATERIALS AND WORKMANSHIP SHALL CONFORM TO THE STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION OF THE OREGON TRANSPORTATION DEPARTMENT HIGHWAY DIVISION

BRIDGE DESIGNED FOR: HS25 WITH AN ALLOWANCE OF [illegible] PSF FOR FUTURE WEARING SURFACE; [illegible] MPH WIND; SPC A SEISMIC ENTIRE BRIDGE UNLESS NOTED OTHERWISE; SPC B SEISMIC APPROACH BENTS AND ABUTMENTS

CONCRETE AND STEEL MEMBERS EXCEPT PILING AND PRESTRESSED MEMBERS DESIGNED BY LOAD FACTOR DESIGN METHOD

STRUCTURE DESIGNED IN ACCORDANCE WITH 1983 AASHTO STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES AS AMENDED BY THE OREGON DEPARTMENT OF TRANSPORTATION

STRUCTURAL STEEL

[illegible]

REINFORCING STEEL

SHALL CONFORM TO ASTM SPECIFICATION A615 GRADE 60. THE FOLLOWING SPLICE LENGTHS SHALL BE USED UNLESS SHOWN OTHERWISE. INCREASE SPLICE LENGTHS SHOWN BY [illegible] FOR ALL EPOXY COATED REINFORCEMENT

ALL REINFORCEMENT EXCEPT END PANELS AND PRESTRESSING STEEL FOR PRECAST BULB I GIRDERS SHALL BE EPOXY COATED AS SPECIFIED

PRESTRESSING STEEL SHALL BE IN ACCORDANCE WITH DETAIL PLANS

ALL BARS SHALL BE PLACED 2" CLEAR OF NEAREST FACE OF CONCRETE UNLESS SHOWN OTHERWISE

PILING

ALL BRIDGE PILING SHALL BE 24" SOLID CORE OCTAGONAL PRESTRESSED CONCRETE AND DRIVEN TO MIN. 150 TON BEARING IN ACCORDANCE WITH THE PROJECT DRIVING SPECIFICATIONS

ALL FENDER PILES SHALL BE 18" SQUARE PRESTRESSED CONCRETE AND DRIVEN TO A [illegible] TIP ELEVATION OF [illegible] UNLESS SHOWN OTHERWISE

ALL TEMPORARY FENDER PILES SHALL BE [illegible] DIAMETER TIMBER AND DRIVEN TO A MIN TIP ELEVATION OF [illegible]

ALL PILES OF BENTS 2 THRU 6 & 9 THRU 12 SHALL BE DRIVEN TO A MINIMUM TIP ELEVATION OF -50.00 AND SHALL SATISFY THE DRIVING REQUIREMENTS OF THE PROJECT SPECIFICATIONS

THE WEST ABUTMENT PILES SHALL BE DRIVEN TO A MINIMUM TIP ELEVATION OF [illegible] AND THE EAST ABUTMENT PILES SHALL BE DRIVEN TO A MINIMUM TIP ELEVATION OF [illegible] FEET. ALL PILES SHALL SATISFY THE DRIVING REQUIREMENTS OF THE PROJECT SPECIFICATIONS

PILE SPLICES SHALL NOT BE USED

CONCRETE:

PRESTRESSED PRECAST BULB I GIRDERS – CLASS 5000 – [illegible]
DECK – CLASS 4000 – 1 1/2"
ALL OTHER – CLASS 3300 – 3/4", 1" OR 1 1/2"
PRESTRESSED PRECAST 24" OCTAGONAL PILING – CLASS [illegible]
PRESTRESSED PRECAST 18" SQUARE PILING – CLASS [illegible]
ALL CONCRETE SHALL RECEIVE A SEALANT COATING IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS

FENDER SYSTEM

TIMBER

ALL TIMBER [illegible] AT FENDER SYSTEMS SHALL CONFORM TO NATIONAL DESIGN SPECIFICATION FOR WOOD CONSTRUCTION [illegible]

ALL TIMBER PILES FOR THE TEMPORARY FENDER SYSTEM SHALL CONFORM TO [illegible]

ALL TIMBER SHALL BE PRESSURE TREATED IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS

MISC. HARDWARE

ALL FENDER SYSTEM MISC. HARDWARE SHALL BE HOT DIP GALVANIZED IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS

CONSTRUCTION NOTE:

[illegible]

GENERAL NOTE:

THESE GENERAL NOTES APPLY TO THE ENTIRE PROJECT INCLUDING THE MOVABLE SPAN. THESE GENERAL NOTES ARE SUPPLEMENTED BY THE GENERAL NOTES FOR THE MOVABLE SPAN INCLUDED ON SHEET B-1.

DATE	REVISION	BY

CH2M HILL

APPROVED: [signature] BRIDGE ENGINEER

D Moyano — DESIGNED
L. Baxter — DRAWN
R.G. Elliott — CHECKED
R.G. Elliott — REVIEWED
REVIEWED

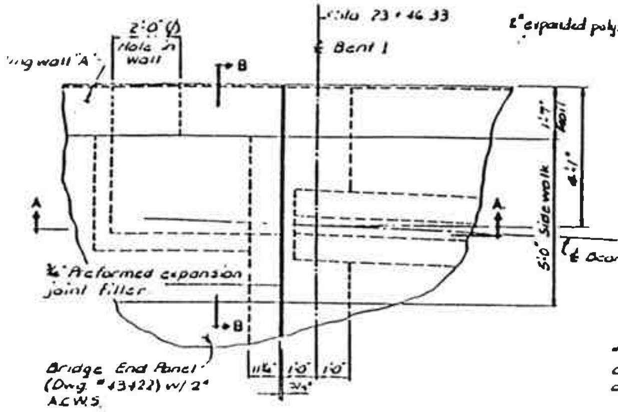
OREGON DEPARTMENT OF TRANSPORTATION
BRIDGE DESIGN SECTION

SOUTH SLOUGH (CHARLESTON) BRIDGE
SOUTH SLOUGH (CHARLESTON) BRIDGE SEC.
CAPE ARAGO HIGHWAY
COOS COUNTY

GENERAL PLAN

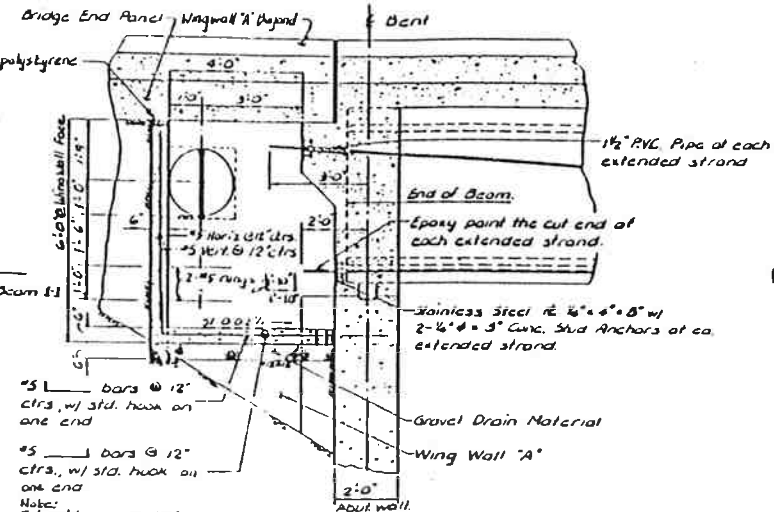
ACCOMPANYING DWGS 42402 thru 42164, 40396, 40971, 31110, 43966, 41497-99, 18302, 40050, 34903, 31126

DATE DEC. 1988 — CALC. BOOK [illegible] — SHEET A-1 OF [illegible]
BRIDGE NO. 18400 — DRAWING NO. [illegible]

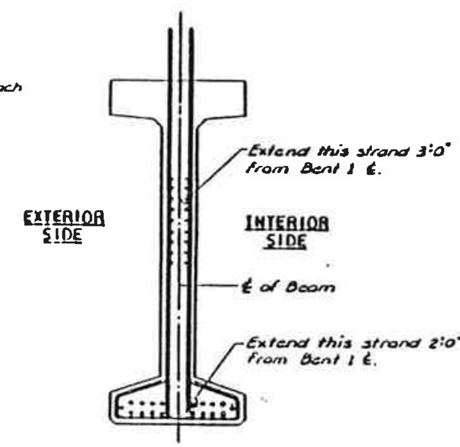


Note: Bend cover plate outwardly for padlock.

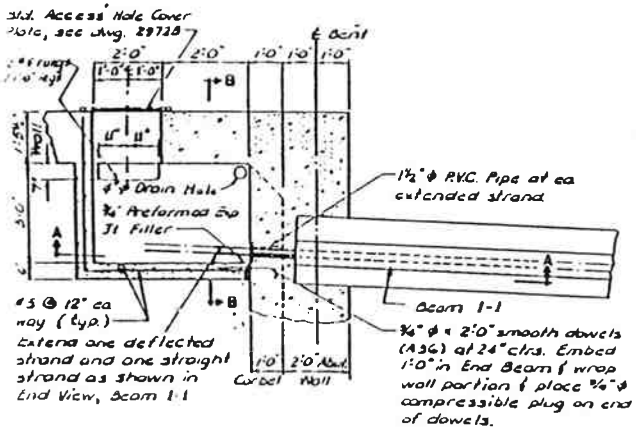
PLAN - BENT 1
Scale: ½" = 1'-0"



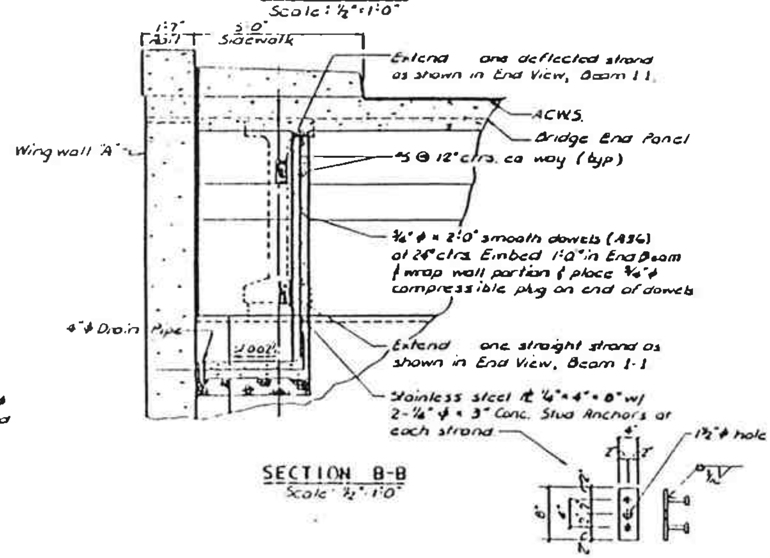
SECTION A-A
Scale: ½" = 1'-0"



END VIEW, BEAM 1-1
Scale: 1" = 1'-0"



PLAN - SECTION
Scale: ½" = 1'-0"



SECTION B-B
Scale: ½" = 1'-0"

NOTE:
For notes not shown, see "General Notes" Dwg. #2901

APPROVED:	OREGON DEPARTMENT OF TRANSPORTATION BRIDGE DESIGN SECTION
Guido Portier	SOUTH SLOUGH (CHARLESTON) BR.
Richard G. Olson	CAPE ARAGO HIGHWAY
Sh. Starkey	COOS COUNTY
J.E. Backstrand	INSPECTION VAULT DETAILS

3-1-89 Dwg. added to contract

DATE Feb. 1989 — SHEET 1 OF 2

APPENDIX B

FIELD SURVEYS RESULTS USED IN CHAMBER CALCULATIONS

TOP DECK ELEVATIONS - IN FEET
BENCH MARK AT 15.39 FEET
STATION 0+00 IS AT WEST END OF GIRDER

Table B-1

	ELEVATION			
STATION	6-15-91	1-13-92	7-28-92	6-15-93
0+00	15.26	15.36	15.39	15.39
0+10	15.61	15.61	15.60	15.62
0+20	15.85	15.86	15.85	15.87
0+30	16.10	16.11	16.09	16.12
0+40	16.41	16.42	16.41	16.43
0+50	16.71	16.73	16.71	16.74
0+60	17.05	17.04	17.03	17.05
0+70	17.36	17.36	17.35	17.37
0+80	17.70	17.70	17.67	17.71
0+90	18.04	18.05	18.01	18.05
0+98 02	18.36	18.36	18.35	18.36

BEAM 1-1 ELEVATION READINGS - IN FEET
TAKEN FROM BOTTOM OF GIRDER
STATION 0+00 IS AT EAST END OF GIRDER

Table B-2

	ELEVATION			
STATION	6-18-91	1-13-92	7-28-92	6-15-93
0+10	11.93	11.93	11.89	11.95
0+20	11.63	11.65	11.61	11.67
0+30	11.34	11.36	11.32	11.38
0+40	11.08	11.07	11.04	11.09
0+50	10.78	10.78	10.73	10.80
0+60	10.48	10.47	10.45	10.49
0+70	10.17	10.18	10.13	10.19
0+80	9.84	9.84	9.81	9.86
0+90	9.53	9.53	9.50	9.55
0+95	9.36	9.36	9.34	NA