EVALUATION OF GRIT-IMPREGNATED, EPOXY COATED PRESTRESSING STRAND on SOUTH SLOUGH (CHARLESTON) BRIDGE Bridge No. 1940G

Construction Report

Experimental Features Project OR 89-06

by

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ABSTRACT

Construction of the South Slough (Charleston) Bridge was completed in March of 1991. The structure was constructed with prestressed concrete beams using grit-impregnated, epoxy coated prestressing strands. While epoxy coated reinforcing steel has been used successfully to combat corrosion for several years, epoxy coating for prestressing strands is a relatively new application. The use of epoxy coated strands did not cause any significant construction problems. The strands and concrete mix were bonded well. The bonding characteristics of the grit-impregnated epoxy prestressed strands to the concrete will be monitored for two years, until March 1993, to detect any loss in bonding.

ACKNOWLEDGEMENTS

Thanks go to project manager Frank Morrison and his crew for their active role in providing inspections during the construction of the structure and for agreeing to continue monitoring the beam for the duration of this study. Also, thanks go to Jim Ezzell, Structural Inspector of the Oregon State Highway Division, for his role during the fabrication of the beam.

DISCLAIMER

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1.0 INTRODUCTION

Oregon's coastal bridges are subject to a severe corrosive environment because of the salt in the marine air. A significant number of coastal bridges are succumbing to the effects of this harsh environment and will be in need of replacement over the next several years. Prestressed concrete bridges will most likely be chosen to replace these deteriorating structures. Corrosive agents can attack the steel reinforcement contained in prestressed concrete, causing tensile stresses which fracture the concrete. Coating the reinforcing steel with epoxy encases and protects the steel from these corrosive agents. While epoxy coated reinforcing steel has been used successfully to combat corrosion for several years, epoxy coating for prestressing strand is a relatively new application.

This construction report provides information on the fabrication and placement of girder number 1-1 of the South Slough (Charleston) Bridge. Girder 1-1 is a Bulb I prestressed beam made with grit impregnated epoxy coated prestressing strands. This is the second structure of its kind to be built in Oregon. The first structure was the Hubbard Creek Bridge, built in 1985.[1]

There are three primary tasks for this experimental features project. The tasks are to: 1) inspect the epoxy coated prestressing strands at the manufacturing yard, 2) inspect the beam's performance after stressing and casting, and 3) monitor the in-place beam for a two-year period, until March 1993.

The grit-impregnated epoxy coated prestressing strand will be monitored for creep, change in camber, and cracking. These characteristics are considered as proof of proper bonding of the prestressed strands to the concrete.

2.0 BRIDGE DESCRIPTION

The South Slough Structure (Bridge No. 1940 G) is located on the Cape Arago Highway (Highway 240) in Coos County. The structure is a coastal bridge subject to a corrosive environment, and it is shown in the vicinity map in Figure 2.0.

The structure is approximately 1192 feet long from the centers of the abutments. The structure has bascule spans near the center to allow ocean vessels passage into the slough. Bridge design drawings showing these spans are included in Appendix C.

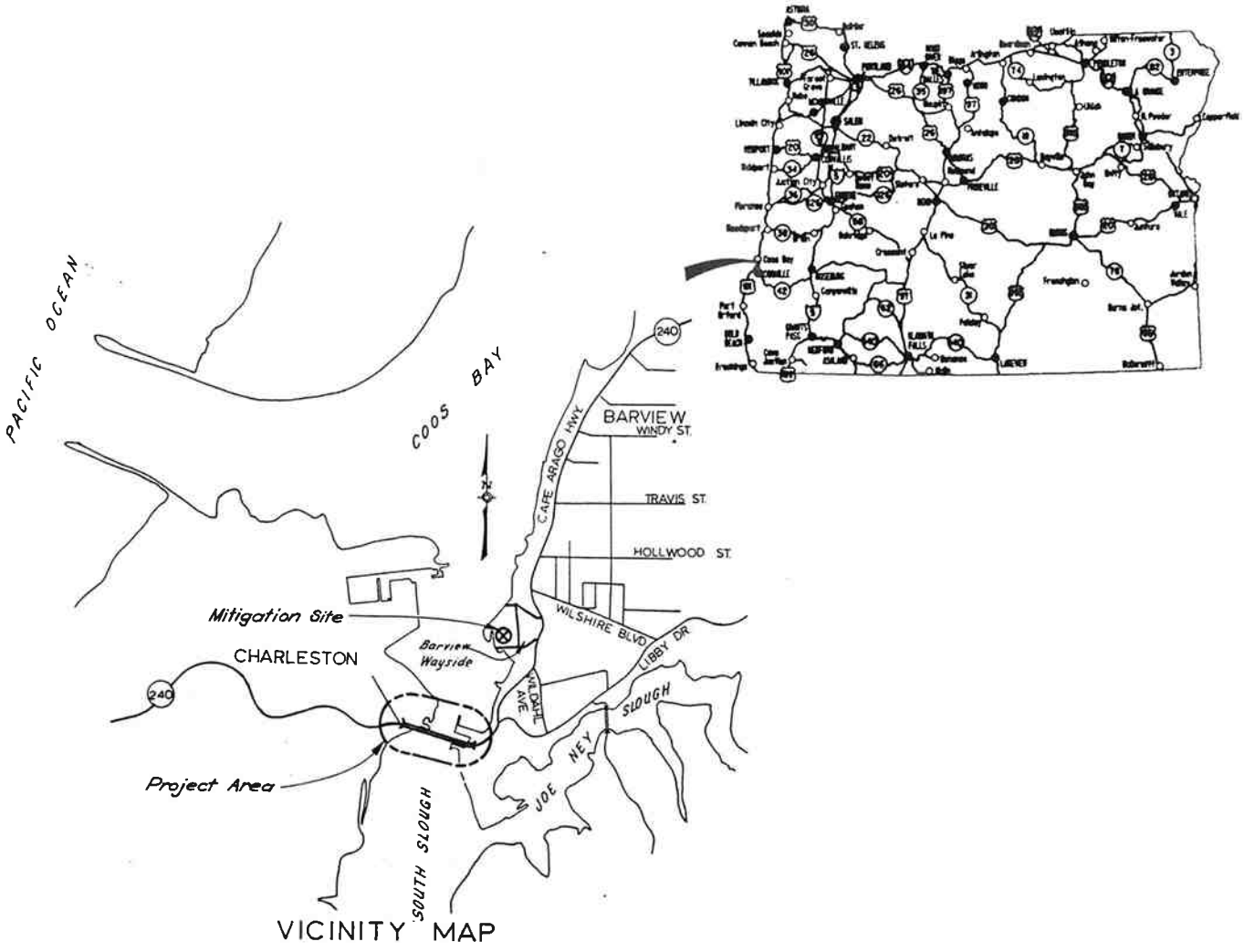


Figure 2.0 Project Location

3.0 FABRICATION OF BEAM

Concrete Technology Corporation of Tacoma, Washington, fabricated the beam (97.3 feet long) using FLO-BOND, a 0.5 inch in diameter, 7-wire, epoxy coated, grit-impregnated strand (each has an ultimate tensile stress of 275 ksi). The strand was manufactured and supplied by Florida Wire & Iron.

The strand was hand-pulled from the coil, fed to the tension pullers, and secured (see figure 3.0). A total of 36 strands were placed, 18 were harped, and the other 18 were straight. The strands were tensioned using four 200-ton rams. An initial pull was made to even the tension on the strands. A second pull tensioned the strands to 103,000 psi. A third pull tensioned each

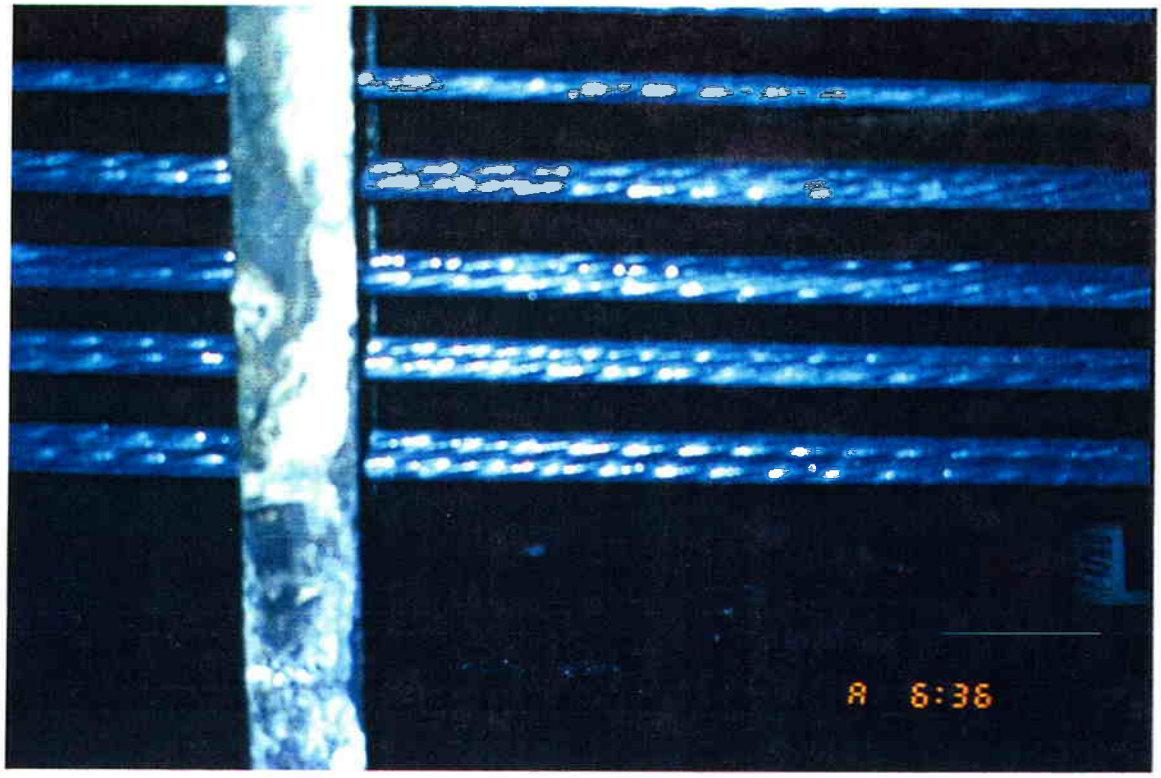


Figure 3.0 Strand Fastened to Tension Puller

strand to 206,000 psi, which is 75% of the strands' 275,000 psi ultimate strength. Total elongation of each strand after the third pull was 22.4 inches.

Inspection of the epoxy coating after the strand was placed and stressed revealed scrapes near the bridles and tie downs. These areas, along with other visible holidays, were patched with a dark blue 3M, epoxy patching paint, provided by Florida Wire & Iron.

The concrete mix used for this beam was batched on site, approximately 50 yards away from the pour. Using a mix design developed by Concrete Technology Corporation (OSHD Lab No. 89-15161), a 5.5 inch slump and a 2.1% air content were obtained. The air temperature during mixing was 40°F and the mix temperature was 62°F. After the concrete pour was completed, the beam was covered and steam cured according to OSHD specifications.

After twelve hours of cure, the first cylinder break was made. The resulting 4,500 psi break did not meet the OSHD 5,500 psi specification requirement. The beam was allowed to cure an additional 2.5 hours; then a second test break resulted in a passing test of 6,210 psi.

Detensioning was performed in three steps. First, the load was reduced to 172,000 psi and held there for ten minutes. Then, the load was reduced to 103,000 psi (same as the second tension force). At this load, the strands were cut and removed from the holders.

After the strands were cut, two reference clamps were mounted, one on a top strand and one on a bottom strand (see Figure 3.1). From these reference points, initial strand measurements were taken. While in storage at the plant, the first set of reference points were damaged. They were replaced and a new set of readings were taken. Both sets of readings can be found in Appendix A.

After fabrication and prior to shipping, all of the beams were sealed with "Hydrozo Silane 40" a penetrating, breathable water repellent sealer, supplied by Hydrozo, Inc. of Lincoln, Nebraska.

Figure 3.1 Reference Clamps

4.0 CONSTRUCTION

General Construction Company and their subcontractor (3 A Construction Company) set span 1, girder 1-1, on May 31, 1990. A two pick point rigging sling was used to pick the girder from the haul vehicle. The girder was set on elastomeric bearing pads placed on top of prepoured grout pads. An inspection vault was built to allow for further strand measurements.

Inspection of the test girder, prior to setting, found it to be free of any cracks or defects, however, the top exposed strand was not long enough to reach through the end wall of the inspection vault. To allow for future measurements of the strand, a six inch PVC block-out was installed through the end wall. The extruding strands were first measured on July 17, 1990, before the deck was poured. These readings were made from the girder to the end of the strands, because the second set of reference clamps were rusting. They are listed in Appendix A.

Girder 1-1 was not field profiled since the typical deck section allowed for a 7.75 inch thick deck with adjusting grades for differing camber. A profile was run underneath the girder after the bridge was finished. These values will be used for comparison during the remaining part of the study and are listed in Appendix B.

Bridge construction was completed and opened to traffic in March, 1991.

5.0 COST COMPARISON

The epoxy coated strand, "Flo-Bond," is only available from Florida Wire and Cable Company. The epoxy coated strand costs approximately $0.49/linear foot, compared to $0.18/linear foot for the same strand uncoated. The costs are for materials only and shipping costs are not included in these prices.

6.0 CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The use of epoxy coated strands caused no significant construction or casting problems. All of the information obtained up to and including the final construction inspection, supports the conclusion that coating of the prestressed strand does not cause any short term bonding difficulties. Monitoring will continue until March 1993.

The material cost for the epoxy coated strand is significantly higher than that of the uncoated strand.

RECOMMENDATIONS

Clamps used for this study proved to be easily damaged, knocked off, and corrosive; therefore, a more reliable strand measuring system should be used on future studies.

7.0 REFERENCES

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

APPENDIX A
STRAND MEASUREMENTS

APPENDIX A
STRAND MEASUREMENTS

Initial Strand Readings in feet - taken when forms were removed on 2/15/90 at 8:30 AM.

Top	Bottom
.517	.569
.518	.570
.518	.568
.519	.569
AVG. .518	.569

Strand Readings while beam stored at the yard.

2/16/90 at 8:00 AM 36°F Air Temperature		2/16/90 at 12:00 Noon 40°F Air Temperature		2/19/90 at 9:00 AM 29°F Air Temperature	
Top	Bottom	Top	Bottom	Top	Bottom
.513	.571	.516	.568	.512	.566
.513	.571	.515	.569	.515	.569
.514	.575	.516	.569	.514	.569
.513	.568	.516	.568	.511	.570
.513	.571	.515	.568	.513	.569
AVG. .513	.571	.516	.568	.513	.569

2/20/90 at 9:00 AM
42°F Air Temperature

Top	Bottom
.512	.567
.513	.568
.513	.569
.512	.569
.513	.567
AVG. .513	.568

NOTE: The reference points had to be reset. The first set of reference points were damaged while in storage at the plant. Jim Ezzell replaced the reference points and made a new set of readings. These readings will be used for comparing future readings.

03/02/90 at 9:30 AM
50° F Air Temperature

	Top	Bottom
	.578	.509
	.578	.509
	.576	.508
	.579	.510
	.579	.510
AVG.	.578	.509

03/06/90 at 10:00 AM
50° F Air Temperature

	Top	Bottom
	.577	.513
	.577	.513
	.577	.513
	.578	.513
	.578	.513
AVG.	.577	.513

Beam shipping Date: May 30, 1990 top: = .577
bottom: = .512

Measurements taken of the strands with the beam in place on structure: Note that the whole length of the strand was measured rather than from the reference point because the second set of reference clamps are rusting.

7/17/91

top: 0.84 foot
bottom: 1.51 foot

APPENDIX B

CAMBER MEASUREMENTS

APPENDIX B

CAMBER MEASUREMENTS

At Release (2/15/90) = 1 9/16 inch
After moved to storage (2/26/90) = 1 13/16 inch
Before shipping (5/30/90) = 2 11/32 inch

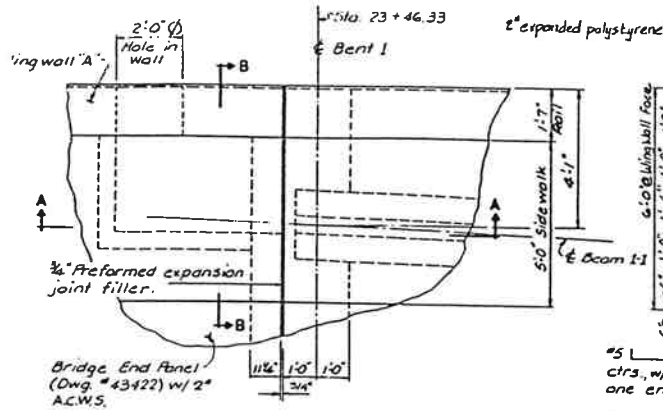
In-place on structure. (6/28/91)

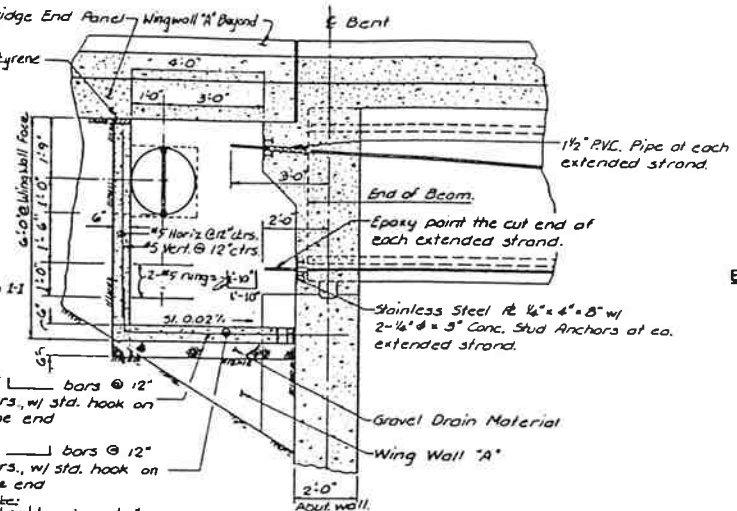
Readings were taken from the bottom of the beam and are as follows.

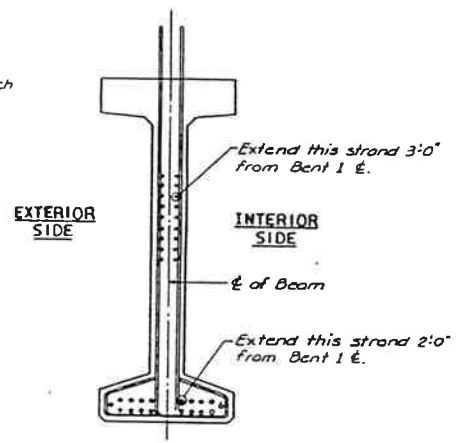
Centerline Stationing	Camber (in feet)
0+00	Started at the west end over the pile cap
0+10	11.93
0+20	11.63
0+30	11.34
0+40	11.08
0+50	10.78
0+66	10.48
0+70	10.17
0+80	9.84
0+90	9.53
0+95	9.36

APPENDIX C

BRIDGE CONSTRUCTION PLANS



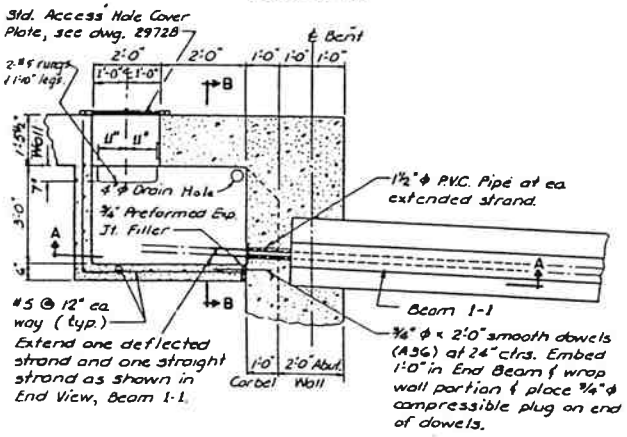




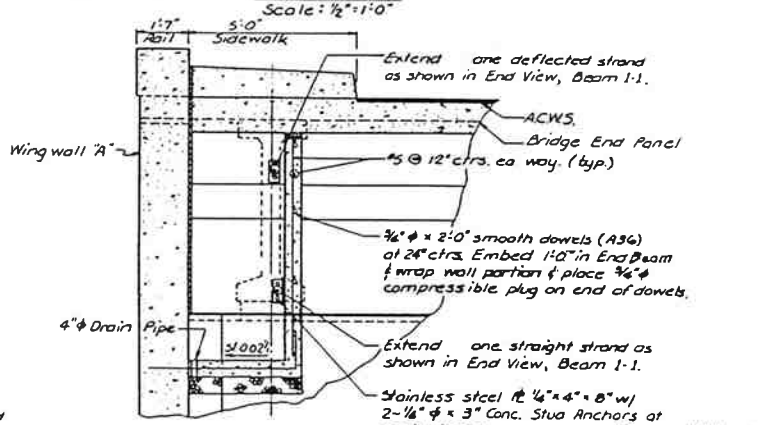
END VIEW, BEAM 1-1
Scale: 1" = 1'-0"

Note: Bend cover plate outwardly for padlock.

PLAN - BENT 1
Scale: ½" = 1'-0"



PLAN - SECTION
Scale: ½" = 1'-0"



SECTION A-A
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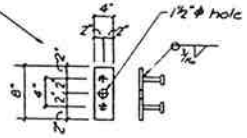

SECTION B-B
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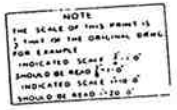


NOTE:
For notes not shown, see "General Notes" Dwg 42901.

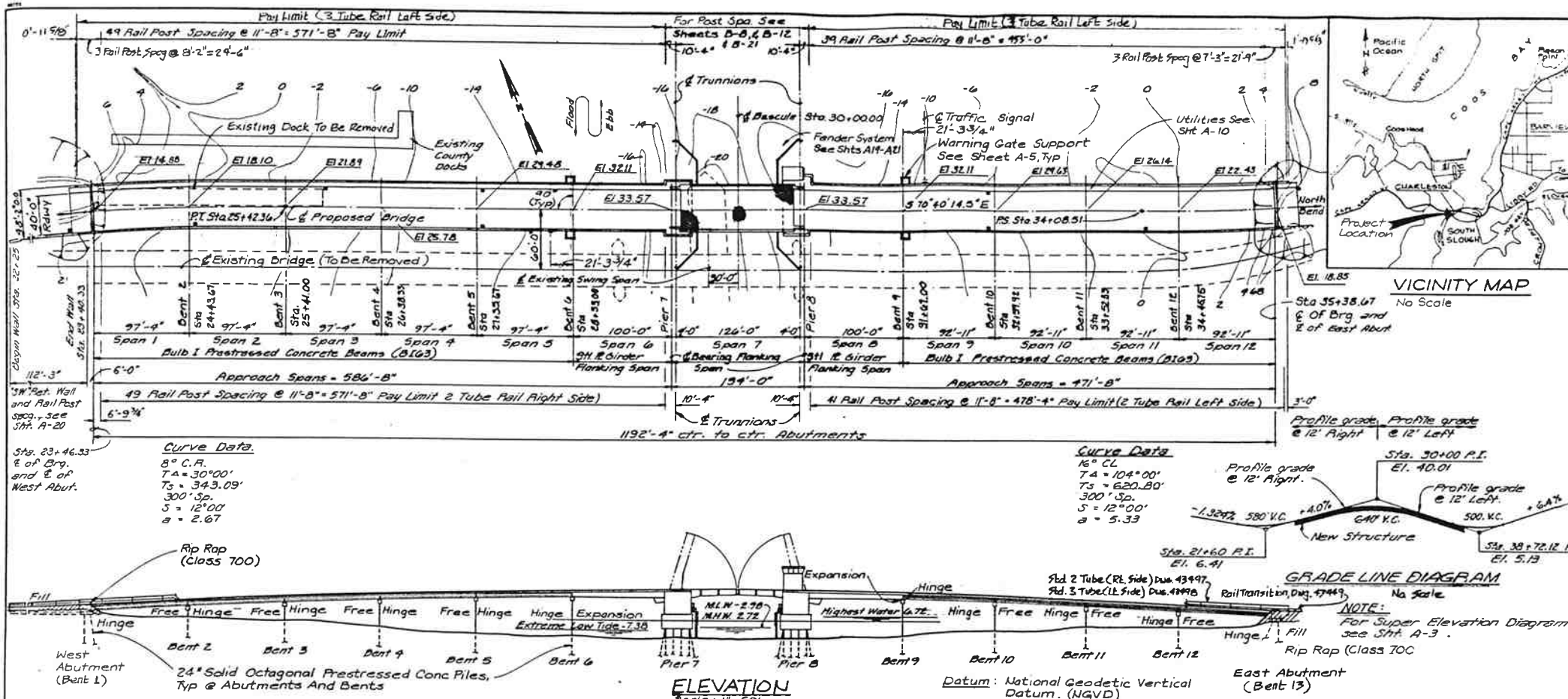
⚠ 3-1-89	Dwg added to contract	TJS

APPROVED:
BRIDGE ENGINEER — PE NO. 4491
Guido Portier — DESIGN — PE NO. 11821
Richard G. Olson — DRAWN
S.K. Starkey — CHECKED
REVIEWED — PE NO. 4491
J.E. Backstrand

OREGON DEPARTMENT OF TRANSPORTATION
BRIDGE DESIGN SECTION

SOUTH SLOUGH (CHARLESTON) BR.
CAPE ARAGO HIGHWAY
COOS COUNTY
INSPECTION VAULT DETAILS

DATE Feb. 1989 — CALC.BOOK — SHEET 1 OF 2
BRIDGE NO. 19416 — DRAWING NO.



GENERAL NOTES

ALL MATERIAL 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 25 PSF FOR FUTURE WEARING SURFACE
80 MPH WIND
S.P.C. A SEISMIC ENTIRE BRIDGE UNLESS NOTED OTHERWISE
S.P.C. 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:

THE GRADE OF STEEL SHALL CONFORM TO ASTM SPECIFICATION A572 UNLESS A COST SAVINGS CAN BE REALIZED BY USING A GRADE OF STEEL CONFORMED TO SPECIFICATION A36 OR OTHERWISE SPECIFIED (EXCEPT FOR PROPRIETARY ITEMS).

ALL ROLLED SHAPES EXCEPT FOR THE TRUNION TOWER COMPONENTS AND STRINGERS ON THE BASCULE LEAF SHALL CONFORM TO ASTM SPECIFICATION A36. ALL BOLTS AT STRUCTURAL CONNECTIONS SHALL BE ⅞ INCH DIAMETER CONFORMING TO ASTM SPECIFICATION A325-F UNLESS NOTED.

WARNING GATE RAILINGS SHALL CONFORM TO ASTM SPECIFICATION A500, GRADE B.

ALL PLATE GIRDERS AND STIFFENERS AND ALL STEEL ON THE TRUNION TOWERS SHALL CONFORM TO ASTM SPECIFICATION A572. ALL STEEL PLATES, BUILT UP MEMBERS AND STRINGERS ON THE BASCULE LEAF SHALL CONFORM TO ASTM SPECIFICATION A572.

ALL BOLTS AT STRUCTURAL CONNECTIONS SHALL BE ⅞" DIAMETER HIGH STRENGTH BOLTS CONFORMING TO ASTM SPECIFICATION A325-F UNLESS SHOWN OTHERWISE, AND SHALL BE COATED WITH INORGANIC ZINC PRIMER PER THE SPECIAL PROVISIONS. HOT DIP GALVANIZED BOLTS SHALL NOT BE USED.

NUTS FOR HIGH STRENGTH BOLTS SHALL BE HEAVY HEX CONFORMING TO ASTM SPECIFICATION A563.

REINFORCING STEEL:

SHALL CONFORM TO ASTM SPECIFICATION A615 (S11) GRADE 60. THE FOLLOWING SPLICE LENGTHS SHALL BE USED UNLESS SHOWN OTHERWISE. INCREASE SPLICE LENGTHS SHOWN BY 50% FOR ALL EPOXY COATED REINFORCEMENT

No. Bar	3	4	5	6	7	8	9	10	11	14 S.U.
Splice Length	1'-6"	1'-9"	2'-0"	2'-6"	2'-9"	3'-1"	3'-5"	3'-9"	4'-1"	Not Used

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 3" CLEAR OF NEAREST FACE OF CONCRETE UNLESS SHOWN OTHERWISE

PILING:

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

ALL FENDER PILES SHALL BE 12" SQUARE PRESTRESSED CONCRETE AND DRIVEN TO A TIP ELEVATION OF -40.00 (-45.00 FOR 24" OCTAGONAL) UNLESS SHOWN OTHERWISE

ALL TEMPORARY FENDER PILES SHALL BE 12" DIAMETER TIMBER AND DRIVEN TO A MIN. TIP ELEVATION OF -40.00

ALL PILES OF BENTS 2 THRU 8 & 9 THRU 12 SHALL BE DRIVEN TO A MINIMUM TIP ELEVATION OF -30.00' AND SHALL SATISFY THE DRIVING REQUIREMENTS OF THE PROJECT SPECIFICATIONS.

THE WEST ABUTMENT PILES SHALL BE DRIVEN TO A MINIMUM TIP ELEVATION OF -23.00 AND THE EAST ABUTMENT PILES SHALL BE DRIVEN TO A MINIMUM TIP ELEVATION OF -23.00 FEET. ALL PILING SHALL SATISFY THE DRIVING REQUIREMENTS OF THE PROJECT SPECIFICATIONS

PILE SPLICES SHALL NOT BE USED

CONCRETE:

PRESTRESSED, PRECAST BULB I GIRDERS — CLASS 6000 - 1";
DECK — CLASS 4000 — 1-1/2",
ALL OTHER — CLASS 3300 — 3/4", 1" OR 1-1/2".
PRESTRESSED PRECAST 24" OCTAGONAL PILING — CLASS 7000 — 1"
PRESTRESSED, PRECAST 12" SQUARE PILING — CLASS 6000 — 1"
ALL CONCRETE SHALL RECEIVE A SEALANT COATING IN ACCORDANCE WITH THE PROJECT SPECIFICATIONS

FENDER SYSTEM

TIMBER:

ALL TIMBER WALERS AT FENDER SYSTEMS SHALL CONFORM TO NATIONAL DESIGN SPECIFICATION FOR WOOD CONSTRUCTION (NDS) 1982 DOUGLAS FIR - LARCH SELECT STRUCTURAL F_c=1800 PSI

ALL TIMBER PILES FOR THE TEMPORARY FENDER SYSTEM SHALL CONFORM TO ASTM SPECIFICATION D1780-78 PACIFIC COAST DOUGLAS FIR F_c=2450 PSI

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

ALL TIMBER IN WALKWAY FOR FENDER SYSTEM SHALL CONFORM TO NATIONAL DESIGN SPECIFICATION (NDS) 1987 DOUGLAS FIR - LARCH SELECT STRUCTURAL F_c=1400 PSI.

MISC. HARDWARE:

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

CONSTRUCTION NOTE:

VERIFY LOCATION OF 8" PRESSURE MAIN AT NORTH SIDE OF BRIDGE PRIOR TO FENDER PILE INSTALLATION. PROVIDE 2' MINIMUM CLEARANCE BETWEEN PILES AND PRESSURE MAIN.

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

REGISTERED PROFESSIONAL ENGINEER OREGON DAVID C. MOYANO

CH2M HILL

APPROVED:
Thomas D. Lulay JR. 8491
BRIDGE ENGINEER

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

NOTE
THE SCALE OF THIS PRINT IS ½ THAT OF THE ORIGINAL DWG. FOR EXAMPLE
INDICATED SCALE 2"=1'-0" SHOULD BE READ 1"=1'-0"
INDICATED SCALE 1"=10'-0" SHOULD BE READ 1"=20'-0"

OREGON DEPARTMENT OF TRANSPORTATION
BRIDGE DESIGN SECTION

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

GENERAL PLAN

ACCOMPANIED BY DWGS. 42902 thru 42986, 40396, 40397, 34448, 43422, 43497-99, 43500, 40050, 34903, 31724

DATE DEC. 1988 CALC. BOOK 2858 SHEET A-1 OF A-2

BRIDGE NO. 19406 DRAWING NO. 42901