EVALUATION OF BOND-CONTROLLED, EPOXY-COATED PRESTRESSING STRAND on HUBBARD CREEK BRIDGE Bridge No. 3339A

Experimental Features Project OR 84-06

Final Report

by

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DISCLAIMER

INTRODUCTION

Oregon's many coastal bridges are subject to a severely corrosive environment, being exposed to frequent rain and fog and a nearly constant misting of salt spray. Heavy rains flush ocean salts off the sides and decks of bridges, but leave the underside covered with salty ocean spray. Because of this spray, coastal bridges are more subject to corrosive attack on the underside than from chlorides applied to the deck. 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 structures, 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 development. An NCHRP study titled "Corrosion Protection of Prestressing Systems in Concrete Bridges" (Project 4-15, FY 1982) was conducted to test the mechanical behavior and corrosion resistance of epoxy coated 7-wire strand used in prestensioning applications. The final report for this study (NCHRP Report 313) concluded that epoxy coated prestressed strand was superior to bare strand wire in both corrosion resistance and bond strength. However, a full scale evaluation of girders in service in the appropriate environment, as opposed to laboratory tests and simulations, was considered essential.

BRIDGE DESCRIPTION

Hubbard Creek Bridge, located on the Oregon Coast Highway (US101) one mile south of Port Orford, was chosen as the experimental project bridge. The new bridge is a 138 foot long, single span structure replacing the existing 40 year old bridge. Due to it's proximity to the ocean and its corrosion history, this bridge site was ideal for testing the effectiveness of the epoxy coated prestressing strand.

Seven prestressed bulb-T beams, six feet high and 139 feet long, were used in the construction of the bridge. Each web contained 26 harped strands, with 26 more strands in the bulb section. The low

relaxation, 1/2" diameter, 7-wire strand was specified to have a minimum epoxy coating of 30 mils, with proprietary grit impregnation to increase bonding capacity.

Incorporated into the design of the replacement structure were several features intended to combat the corrosive effects of the marine environment. These features included:

1. The use of 3" minimum concrete cover over the reinforcement wherever practical (everywhere except the precast, prestressed bulb-T girders);

2. The use of a waterproof coating on all exposed concrete surfaces except the roadway;

3. The use of epoxy coated reinforcing bars throughout; and

4. The use of low relaxation, bond-controlled, epoxy coated prestressing strand in the bulb-T girders.

EVALUATION PROCEDURE

The preconstruction evaluation included investigating the condition of the epoxy coated prestressing strand in the yard, and its performance after stressing but before casting of the girders. The constructed girders were also evaluated during placement and periodically for the first five years of service. At each post construction inspection, the web and bottom flange surfaces of the girders were observed for cracking, and the midspan deflection was recorded relative to a fixed frame of reference. Additionally, the creep and the deflection of the girders was monitored. These last two measurments were considered necessary to verify the proper bonding of the strands to the concrete.

Eight strands were left extended in beam number seven (four srands at each end), and the ends of these strands were measured relative to a fixed reference point. Inspection vaults were constructed at both end bents to monitor slippage of the prestressing strands (four at each end). See figure 2 in Appendix E for details on the method of strand measurement.

The five year evaluation period was probably insufficient to evaluate the coating's effectiveness in preventing corrosion, but it was long enough to determine any structural performance problems with girders constructed with epoxy-coated prestressed strands.

PRECONSTRUCTION EVALUATION

On April 10, 1985, inspections were made of the epoxy coated strand as it emerged from the guide ring of its original shipping coil in the plant of the precaster. Most of the strand appeared to be coated uniformly, with a fairly consistent grit impregnation and a surprising range of blue and blue-green colors.

In some areas on one coil, the coating had loose flakes underlaid by a tighter coating layer, with less grit density and less apparent coating thickness between individual wires of the strand. With the removal of the loose material and verification of the underlying coating thickness and integrity, the strands were accepted for use in the middle of the section's bulb.

Due to the abrasive surface of the coated strand, installing the strand after stirrups were in place would damage the epoxy coating. To prevent this, the strands were raised off the stirrups with temporary wooden blocks, which were removed after the strands were in place.

After casting, the epoxy strand could not be released until the concrete surface temperature cooled to approximately 120 degrees F. This caused no delay or additional expense, as the contractor was able to schedule stripping and form work during this time.

A girder, cast the previous day, was inspected for apparent cracking, spalling, and evidence of strand slippage. The initial camber was approximately 4", as compared to the predicted 2-7/8 ". This excessive camber may have been due to excellent bonding or, because of the relatively early release time, the concrete may not have reached the anticipated elastic modulus. In either case, the large camber is indicative of adequate initial bonding.

A small number of very thin vertical cracks were observed near the "dead" end of the beam. These cracks are possibly the result of horizontal friction in the supports resisting shrinkage. Another possibility is stress differential during detensioning in the region where the strands had not developed enough to introduce significant compression into the ends of the member. These cracks were considered insignificant by the State Inspectors.

Camber was measured after the release of the girders, and varied from 3-7/6" to 3-15/16" for all beams. Again, this large camber is indicative of excellent bonding between the strand and concrete. After erection of the girders and before pouring the deck, camber measurements were reasonably consistent with the anticipated long term camber projections.

POST-CONSTRUCTION EVALUATION

Construction of the Hubbard Creek Replacement Bridge was completed September ,1985, as scheduled. As outlined in the workplan, the finished deck grades were regularly monitored. The maximum midspan deflection was 0.08′ during the first 5 months immediately following construction. This difference includes deflections that occurred due to the pouring of bridge parapets. Cracking was not observed on the web or bottom flange surfaces of any girder.

Measurements taken on the extended strands showed no measureable movement or slippage had taken place.

LONG TERM MONITORING

Grade measurements on the bridge deck and strand measurements in the inspection vaults were made from 1985 to 1990 by the project manager′s field crew. Visual inspections of the bridge were made by the Region 3 Bridge Inspector every two years. There have not been any significant changes measured or observed in the structure during this time period. The maximum deflection recorded over this time period has been 0.05′. No measureable movement or slippage of the epoxy-coated prestressed strands was detected. See Appendixes A-D for the detailed field measurements and inspection reports.

The inspections and monitoring of the deck and the girders have been continued through the fifth year of service. The data from these inspections have been analyzed, and are included in this report.

COST COMPARISON

The epoxy coated strand, "Flo Bond", is only available from Florida Wire and Cable Company. It is approximately $0.45/lin. ft., compared to $0.195/lin. ft. for the same strand uncoated. Using the epoxy coated prestressing strand on the Hubbard Creek Replacement Bridge added $14,030 to the $134,760 cost of the beams. This increased the total cost of the beams by 10.4% and added 4.3% to the total price of the bridge.

Special chucks and jaws were required to handle the epoxy coated strands at the yard. These tools, while expensive, can be used again on any project utilizing epoxy coated strand. The one time cost of these tools was $3,043.

No other costs which could be attributed to the use of epoxy coated strands were reported in casting the beams or during the field installation.

CONCLUSIONS

The use of epoxy coated strands caused no significant construction or casting problems. All evidence received supports the conclusion that epoxy coating of the prestressed strand does not cause any short term bonding difficulties. Monitoring was continued for five years during which time no signs of debonding appeared.

The use of epoxy coating on prestressing strand will be considered for all future applications in marine environments. More data will be collected from this project in the future for additional long-term evaluation. Epoxy-coated prestressed strands have also been used in beams on the South Slough (Charleston) Bridge (Experimental Feature 89-06). This project will be evaluated over the next three years and will provide additional data on the use of this type of corrosion prevention technique. Based on information from this study and the NCHRP report the use of epoxy-coated prestressed strands appears to be a benifical and viable option for use in reducing the corrosion potential of coastal highway bridges.

APPENDIX

Form 734-3034 SP*70535-734

Date Party

Line Staked

Project HUBBARD CR. BRIDGE

CONTINUED FINISH GRADE

LEVEL SHEETS

Oregon State Highway Division

PROFILE OF 7/3/85

STA	20° LT		℄		20° RT
67+77 50	52 05		51 75		51 45
+80	52 00		51 68		51 36
+90	51 73		51 38		51 03
68 —	51 49		51 09		50 67
+10	51 26		50 82		50 38
+20	51 04		50 56		50 08
+30	50 82		50 30		49 78
+40	50 63		50 06		49 49
+50	50 43		49 82		49 21
+60	50 25		49 60		48 95
+70	50 08		49 39		48 70
+80	49 92		49 18		48 44
+90	49 77		48 97		48 21
69 —	49 63		48 81		47 99
+10	49 51		48 64		47 77
+15 50	49 44		48 55		47 66
68+25			50 43		
68+75			49 27		

20° LT		℄		20° RT	
52 06		51 72		51 43	67+77 50
					+80
51 74		51 35		51 04	+90
51 50		51 10		50 76	68 —
51 29		50 85		50 47	+10
51 07		50 66		50 17	+20
50 88		50 37		49 87	+30
50 65		50 12		49 62	+40
50 48		49 87		49 35	+50
50 29		49 65		49 05	+60
50 12		49 44		48 78	+70
49 96		49 24		48 54	+80
49 79		49 02		48 29	+90
49 63		48 81		48 04	69 —
		48 62			+10
49 47		48 58		47 69	+15 51
ELEV. TAKEN BEFORE					
POURING PARAPETS AND					
WINGWALLS.					
℄ 68+25		℄ 68+75			
50 49		49 34			

Finished Grade Profiles of Bridge Deck

APPENDIX B

Finished Deck Grades

1985-1990

Const. Line Staked Date Party

Project Hubbard Cr. Br. Monitoring

Sta 67+77.5

Date	20'Lt	℄	20'Rt		
Computed	52.05	51.75	51.45		
7/3/85	52.06	51.72	51.43	Before Parapets	
12/16/85	52.05	51.75	51.41		
1/29/86	52.02	51.68	51.42		
2/19/86	52.02	51.68	51.41		
3/12/86	52.02	51.69	51.41		
3/31/86	52.02	51.68	51.41		
5/28/86	52.02	51.68	51.41		
7/11/86	52.03	51.70	51.42		
1/7/87	52.03	51.69	51.42		
5/13/87	52.02	51.69	51.41		
7/17/87	52.02	51.69	51.40		
10/6/87	52.02	51.70	51.42		
1/8/88	52.02	51.68	51.40		
4/28/88	52.01	51.68	51.40		
10/3/88	52.03	51.70	51.42		
6/14/89	52.01	51.68	51.40		
4/13/90	52.01	51.69	51.40	Lost Monitor	

APPENDIX B

Finished Deck Grades

1985-1990

Oregon State Highway Division
LEVEL SHEETS

Sta 68+50

Date	20'Lt	℄	20'Rt		
Computed	50.43	49.82	49.21		
7/3/85	50.48	49.87	49.35	Before Parapets	
12/16/85	50.39	49.82	49.27		
1/29/86	50.41	49.83	49.29		
2/19/86	50.40	49.83	49.29		
3/12/86	50.41	49.83	49.29		
3/31/86	50.41	49.83	49.29		
5/28/86	50.40	49.83	49.29		
7/11/86	50.43	49.86	49.32		
1/7/87	50.41	49.83	49.29		
5/13/87	50.42	49.83	49.30		
7/17/87	50.41	49.83	49.29		
10/6/87	50.41	49.84	49.30		
1/8/88	50.41	49.82	49.29		
4/28/88	50.40	49.82	49.29		
10/3/88	50.43	49.85	49.31		
6/14/89	50.40	49.84	49.29		
4/13/90	50.40	49.84	49.29	Lost Monitor	

APPENDIX B

Finished Deck Grades

1985-1990

Const. Date Line Staked 12/16/85 - 4/13/90 Party

Project Hubbard Cr. Br. Monitoring

Sta. 69+15 ℄

Date	20'Lt	℄	20'Rt.		
Computed	49 44	48 55	47 66		
7/3/85	49 47	48 58	47 69	Before forapet	
12/16/85	49 44	48 55	47 66		
1/29/86	49 44	48 56	47 69		
2/19/86	49 44	48 56	47 69		
3/12/86	49 44	48 55	47 69		
3/31/86	49 44	48 56	47 68		
5/28/86	49 41	48 54	47 66		
7/11/86	49 46	48 57	47 72		
1/7/87	49 44	48 56	47 69		
5/13/87	49 42	48 55	47 67		
7/17/89	49 42	48 54	47 67		
10/6/87	49 43	48 54	47 65		
1/8/88	49 43	48 53	47 66		
4/28/88	49 42	48 53	47 66		
10/3/88	49 43	48 54	47 68		
6/14/89	49 41	48 53	47 66		
4/13/90	49 41	48 53	47 66	Last Monitor	

S- 396

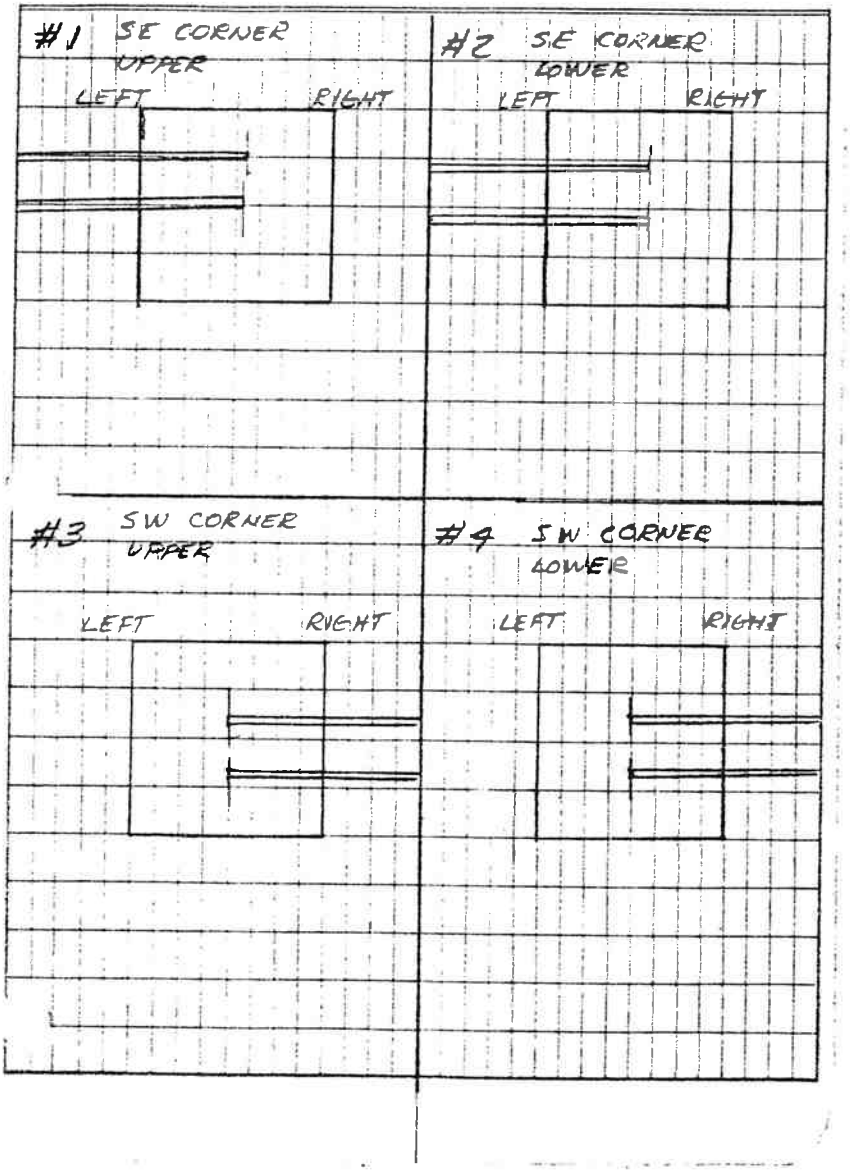
APPENDIX C

Strand Displacement

(vault layout)

Oregon State Highway Division
TRANSIT SHEET

INSPECTION VAULTS



APPENDIX C

Strand Displacement

(First quarter)

MONITOR Line Staked 12-16-85 Party J. ROLLE B. FERGESON S. DOCKINS G. ETHERTON

Project HUBBARD CR BRIDGE INSPECTION VAULTS

PLATE	DATE	MOVEMENT LEFT	MOVEMENT RIGHT	REMARKS
#1	11-08-85			INT. READING
SE COR	12-16-85	0.00	0.00	
UPPER	3-31-86	0.00	0.00	
	See next Set of Notes			
#2	11-08-85			INT, READING
SE COR	12-16-85	0.00	0.00	
LOWER	3-31-86	0.00	0.00	
		11		
#3	11-08-85			INT READING
SW COR	12-16-85	0.00	0.00	
UPPER	3-31-86	0.00	0.00	
		11		
#4	11-08-85			INT. READING
SW COR	12-16-85	0.00	0.00	
LOWER	3-31-86	0.00	0.00	
		11		

Form 734-3034 SP*70535-734

CONST Line Date Staked ..... Party .....

Project HUBBARD CR. BR.

INSPECTION VAULT #2 67+75 ±

DATE	UPPER PLATE UPPER STRAND	UPPER PLATE LOWER STRAND	LOWER PLATE UPPER STRAND	LOWER PLATE LOWER STRAND	
12/16/85	0	0	0	0	INITIAL
1/29/86	0	0	0	0	
3/17/86	0°	0°	0°	0°	
3/12/86	0°	0°	0°	0°	
5-28-86	0°	0°	0°	0°	
7-11-86	0°	0°	0°	0°	
1-7-87	0°	0°	0°	0°	HUK
5-13-87	0°	0°	0°	0°	HUK
7-13-87	0	0	—	0	HUK
10/6/87	0	0	0	0	
1-8-88	0	0	0	0	
4-28-88	0	0	0	0	
10-3-88	-.005	.0	*.0	*.0	
4-12-90	-.005	.0	*-.02	.0	TA.
			*INDICATOR DAMAGED		
*					
		*	* NOTE: RESTRAINING STRAND BROKEN (RUST.)		

LEVEL SHEETS

Oregon State Highway Division

INSPECTION VAULT #2 69+15 ±

DATE	UPPER PLATE UPPER STRAND	UPPER PLATE LOWER STRAND	LOWER PLATE UPPER STRAND	LOWER PLATE LOWER STRAND	
12/16/85	0	0	0	0	INITIAL
1/29/86	0	0	0	0	
3/17/86	0°	0°	0°	0°	
3/12/86	0°	0°	0°	0°	
5-28-86	0°	0°	0°	0°	
7-11-86	0°	0°	0°	0°	
1-7-87	-0.005	0°	0°	0°	HUK
5-13-87	-0.005	0°	0°	0°	HUK
7-17-87	-0.005	0	0	0	HUK
10/6/87	0	0	0	0	
1-8-88	0	0	0	0	
4-25-88	UNREADABLE DUE TO OTHER LOAD				
10-3-88	-.005	0	0	0	
4-12-90	0	0	0	-.02	TA.

APPENDIX D

BRIDGE INSPECTION REPORT
OREGON STATE HIGHWAY DIVISION

BRIDGE NO. 03339A

138' Prest. RCDG

BRIDGE TYPE 462: ~~RC Cont T BEAM~~ NAME Hubbard Creek (STATE) FAS, FAU, OS) HWY. NO. 009

CROSSING (OVER, ~~UNDER~~) Creek Rd4 COUNTY Curry INSP. FREQ. Odd MILE POST 302.28

DISTRICT 07 YEAR BUILT 1942 A.C. (in.) ____ DATE 11/20/85 INSPECTORS' SIGNATURES Gary L. Bowling

AR = As Repaired
OM = Original Member

SUBSTRUCTURE (60)		AR	OM
1. END BENTS	Caps		9
	Piles		—
	Footings		9
	Footing Piles		—
	Backwalls, Bulkheads		9
	Wings		9
			—
2. INTERIOR PIERS OR BENTS	Caps		
	Columns, Posts		
	Footings		
	Footing Piles		
	Piles		
	Bracing		
3. Debris on Seats			
4. Paint			—
5. Collision Damage			
6. Scour			N
7. Settlement (Footing or Piling)			9
INSPECTOR'S CONDITION RATING (60)			9
CHANNEL & CHAN. PROTECT. (61)			
1. Channel Scour			8
2. Embankment Erosion			8
3. Drift			8
4. Vegetation			8
5. Channel Change			N
6. Fender System			—
7. Spur Dikes & Jetties			—
8. Riprap			8
9. Adequacy of Opening			8
INSPECTOR'S CONDITION RATING (61)			8

OBSERVATIONS

SUPERSTRUCTURE (59)		AR	OM
1. Stringers			—
2. Girder or Beams (Bulb-T)			9
3. Floor beams			—
4. TRUSSES	Chords		
	Web Members		
	Portals		
	Bracing		
5. Diaphragms, Bridging			9
6. Bearing Devices			9
7. Paint			9
8. Rivets or Bolts			—
9. Welds			—
10. Collision Damage			N
11. Deflection under Load			9
12. Alignment of Members			9
13. Vibrations under Load			9
14. Machinery (Movable Spans)			—
INSPECTOR'S CONDITION RATING (59)			9
CULVERTS & RETAIN. WALLS (62)			
1. Barrel or Wall	Concrete		
	Steel		
	Timber		
2. Headwall & Parapet			
3. Aprons			
4. Wingwalls			
5. Adequacy			
6. Debris			
INSPECTOR'S CONDITION RATING (62)			—

(Rating Guide on back of sheet)

DECK (58)	Condition Rating
1. Deck — Structural Condition	9
2. Wearing Surface (AC)	9
3. Deck Joints	—
4. Curbs, Felloe Guards	—
5. Sidewalks	—
6. Parapet, Concrete Barrier	9
7. Railing, Posts	—
8. Median Barrier, Railing	—
9. Paint	9
10. Drains	9
11. Lighting Standards	—
12. Utilities	7
13. Vibrations in Deck	9
INSPECTOR'S CONDITION RATING (58)	9
APPROACH CONDITION (65)	
1. Pavement & Embankment	9
2. Shoulder Embankment	9
3. Relief Joints	—
4. Approach Slab	—
5. Guardrail	9
INSPECTOR'S CONDITION RATING (65)	9
SAFETY FEATURES (36)	1 1 1 1
APPR. ALINE. (72)	8
SIGNING	
1. Posted Loading	—
2. Legibility	—
3. Visibility	—
INSPECTOR'S CONDITION RATING	—

REMARKS (Key-in to item and number above)

(58-12) On the west side on each end of the bridge is a metal hatch that I would guess to be for ~~utilities~~. Need a lock on the inspection vault hatch doors. (Br. Inspection Vault)

MAINTENANCE RECOMMENDATIONS

PREFIX	ITEM	COSTS ESTIMATED	COSTS ACTUAL	REPAIRS COMPLETE
—	Place lock on the inspection vault doors	50.00		