DESERT VARNISH
ROCKY POINT VIADUCT

FINAL REPORT

Experimental Features #94-02B

RESEARCH
UNIT

Oregon Department of Transportation

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by

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Federal Highway Administration
Washington, D.C. 20590

November 1998

1. Report No.	2. C PB99-119109	3. Recipient's Catalog No.
OR-EF-99-09		

4. Title and Subtitle	5. Report Date
Desert Varnish Rocky Point Viaduct Final Report	November 1998
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
Eric W. Brooks, E.I.T.	

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Oregon Department of Transportation Research Unit 200 Hawthorne SE, Suite B-240 Salem, Oregon 97301-5192	
	11. Contract or Grant No.

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
Oregon Dept. of Transportation Research Unit 200 Hawthorne SE, Suite B-240 Salem, Oregon 97301-5192 and Federal Highway Administration Washington, D.C. 20590	Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

In 1995, ODOT sprayed the reinforced shotcrete slope stablilization project near Port Orford on US 101 with Permeon, a rock coloring material also called desert varnish. The application colored the shotcrete to a weathered-looking dull brown, masking its gray-white concrete appearance. Some weathering in the last three years has changed the color. Water and mud running from the above cliff have added white and brown streaks. Also, wind and salt air erosion have faded some of the coloring. The test area is still darker than the control section which received no application.

The value of the desert varnish appears to be marginal. If the three-year trend continues, the salt air and strong winds will discolor the entire treatment.

17. Key Words	18. Distribution Statement
Desert varnish	Available through the ODOT Research Unit

19. Security Classification (of this report)	20. Security Classification (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	21	

Technical Report Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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 C + 32	Fahrenheit	□F

* SI is the symbol for the International System of Measurement

(4-7-94 jbp)

ACKNOWLEDGEMENTS

The authors would like to thank the following Oregon Department of Transportation (ODOT) personnel for their contributions: Kaaren Hofmann, Laura Lesher, Jim Risley and Sue D'Agnese.

DISCLAIMER

DESERT VARNISH: ROCKY POINY VIADUCT
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1.0 INTRODUCTION

Desert varnish is the name given to the brown to black coating that forms on stable rock surfaces in certain arid regions of the world. Desert varnish can be found in the Sahara Desert and the cold, dry deserts of Antarctica, Australia and the southwestern United States. It also appears in arid, high-altitude mountains in Germany, Colorado and Montana. No one has observed the natural formation of desert varnish, an extremely slow geological process that may take up to 200,000 years to form.

Unfortunately, the deformation or removal of desert varnish takes only seconds. The single pass of a bulldozer leaves a highly reflective scar of freshly exposed rock. To re-create the desert varnish look, a process was developed that would artificially create the natural earth tones requiring thousands of years to form naturally. Initially, laboratory-created desert varnish was applied to mountainous areas in Arizona, where reseeding and other reclamation efforts would not be feasible. Mining companies included desert varnish in their reclamation programs to comply with visual impact laws. State and federal highway departments specified desert varnish for color restoration of road cuts in visually sensitive areas. More applications were added when it was found that concrete could also be colored to match existing earth tones.

The purpose of this report is to describe the appearance of the laboratory-made desert varnish after three years of service.

1.1 BACKGROUND

Rocky Point Viaduct is located on the Oregon Coast Highway (US 101) just south of the city of Port Orford. The project area is highly visible to motorists from the north and south. When the existing bridge at Rocky Point was replaced in 1994, large cuts were made on the hillside. These cuts were made in unstable rocks and needed tieback-rods and shotcrete to gain stability. Because of the scenic nature of the area, it was desirable for the reinforced shotcrete facing of the rock slope stabilization to blend into the natural surroundings.

The Oregon Department Of Transportation (ODOT) selected Permeon to be sprayed on approximately 2,360 square meters of the exposed shotcrete surfaces. This product is also known as desert varnish because it gives the rocks a dark brown weathered look. The goal was to have newly applied shotcrete look like "old rocky cliffs". The desert varnish was easy to apply and dramatically improved the appearance of the shotcrete rock slope stabilization at Rocky Point. Details of the process are described in the "Desert Varnish: Rocky Port Viaduct Construction Report." The construction report noted that inclement weather and the application of curing compounds to the concrete could cause problems in applying the treatment. Recommended sample construction specifications from the State of Nevada can be found in Appendix A.

1.2 OBJECTIVE

The objective of this project was to evaluate the performance of desert varnish over three years. The evaluation plan was to compare photographs taken every six months. This goal was not met but pictures were taken at least once a year.

2.0 LOCATION

The project is located on US 101 at milepost 304, just south of Port Orford on the Oregon coast. Figure 2.1 is the location map and Figure 2.2 shows the high visibility of this project to the motoring public.

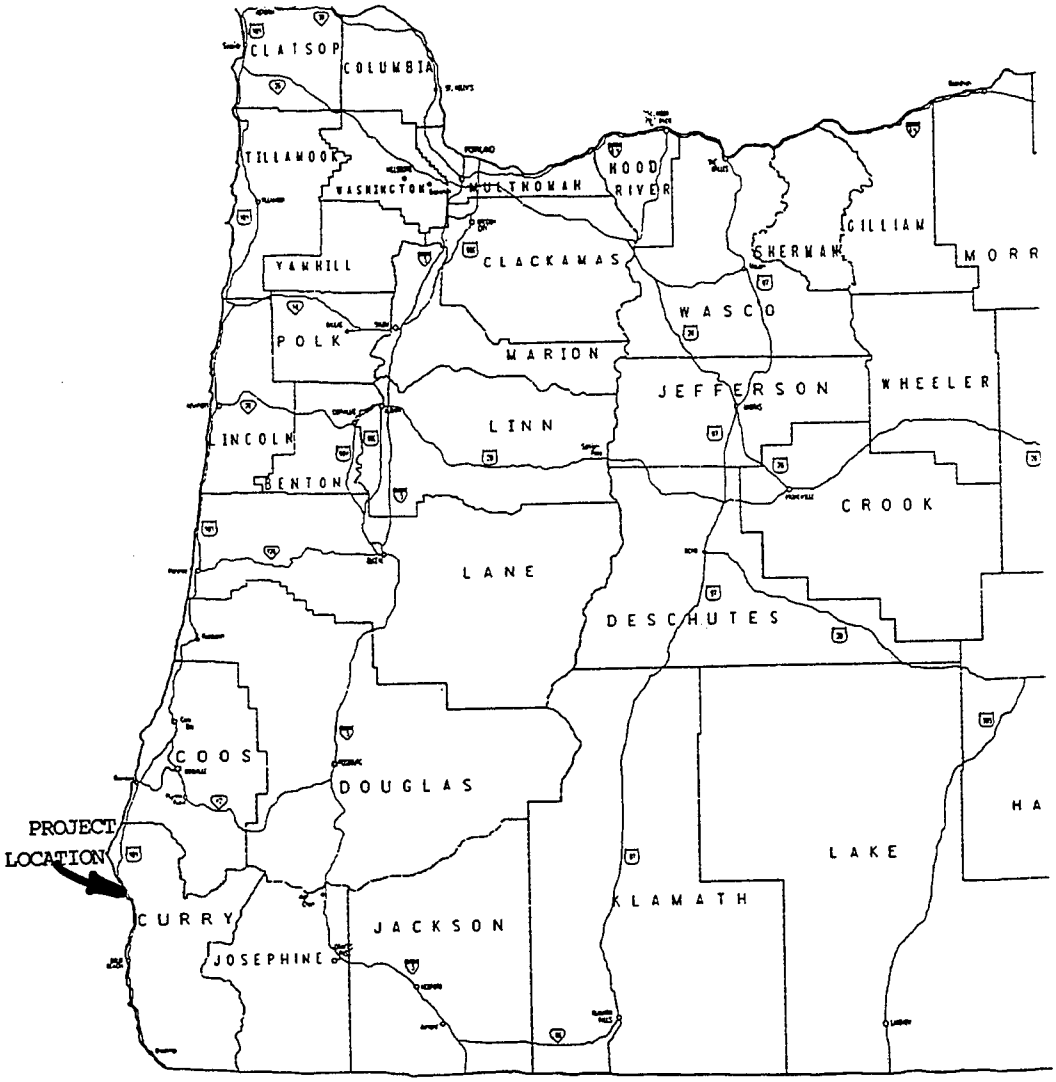

Figure 2.1: Project Location.

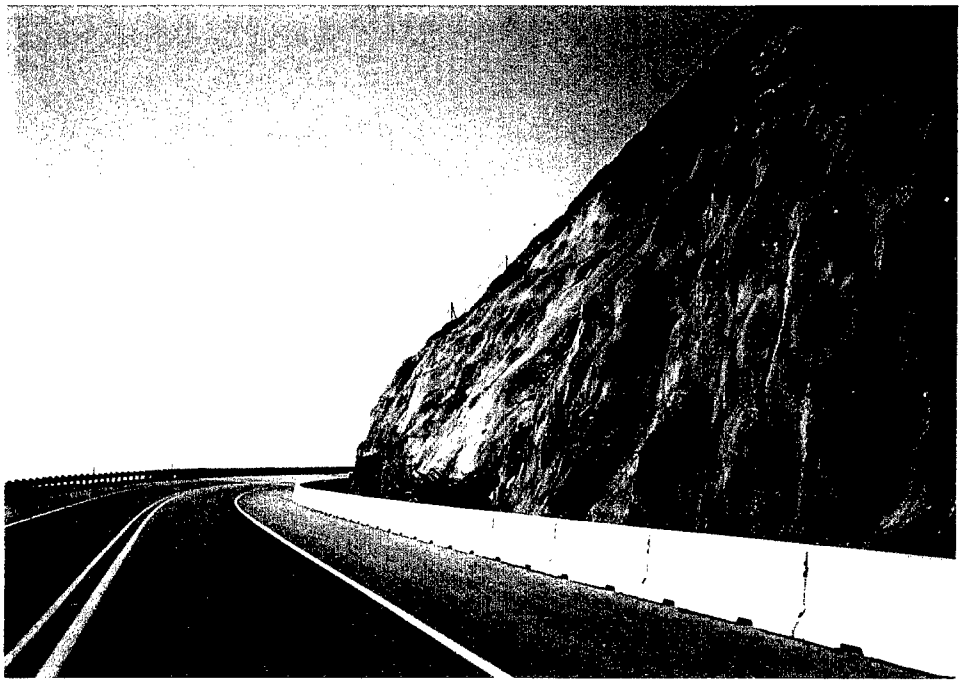

Figure 2.2: Motorist View of the Desert Varnish Cliff.

3.0 EVALUATIONS

The cliff at Rocky Point Viaduct was observed and photographed five times after the application of the Permeon was complete: after one month, one year, twenty months, twenty nine months, and three years. The pictures appear in Figures 3.1 through 3.10.

3.1 POST CONSTRUCTION INPECTION

One month after the desert varnish was applied, a post construction inspection revealed that the varnish was performing well. There was a dramatic difference in the appearance of the shotcrete stabilization on the rock slope before and after the application of desert varnish as shown in Figures 3.1 and 3.2. From a distance, it was difficult to tell that the desert varnished slope was covered in shotcrete.

3.2 ONE YEAR INSPECTION

One year after application, October 30, 1996, the dark brown shade of the desert varnish remained on most of the shotcrete. However, minor flaws began to appear. White streaks (caused from water run-off from the hill above) were seen in a few sections. Also, some of the shotcrete was flaking off in two small areas. About thirty percent of the varnished area had been covered by a rock-fall cable system, masking the cliff's natural appearance (See Figure 3.3).

In 1996, the Port Orford area had a record amount of rainfall of 2.69 m. The mean annual rainfall for this area is about 1.85 m. As indicated on the graph in Figure 3.4, January and February of 1996 had above normal rainfall, as did November to December 1996 and January of 1997. It was some time during this period that the shotcrete slabs broke at the base. Other slide problems occurred in this section of 101 during this record rainfall winter. The resulting cut slope after repair is shown in Figure 3.5. Note the resemblance of the brown slope to the colored shotcrete.

3.3 TWENTY MONTH INSPECTION

The section was inspected again on July 8, 1997, 20 months after application. The shotcrete in a section about 30 m long, near the south end of the test area, had been damaged. Three rectangular blocks about 1.6 m high and 1.6 to 4 m wide had separated from the main body of the shotcrete. (See Figure 3.6). These blocks were near the bottom of the shotcrete and appeared to have broken at a point where the slope changed to a vertical drop. Not only were they loose from the main section, but were also separated by 0.6 m and tilted slightly toward the roadway. A pine tree about 8 m long and 250 mm at the base, had slid down from the top of the cliff. It was just few meters to the north of the damaged area.

In general, the desert varnish looked very natural. The original dark brown color had faded. Also, white and brown streaks from the water and mud running over the cliff produced a multi-colored pattern. This same type of color pattern was observed on non-treated cliffs in the area. A few plants had sprouted on the desert varnish. Clumps of grass were seen near the plastic pipe drains. Also, some other plants were growing near the top edge of the shotcrete.

3.4 TWENTY-NINE MONTH INSPECTION

On March 23, 1998 another inspection found that overall, the shotcrete had a natural weathered appearance. Water stains and mud from the cliff above the shotcrete had caused white and brown streaking which would occur on a natural cliff . The sun and wind had also caused the dark brown desert varnish to fade. Erosion also caused the mounds at the tie-rod holes to round out and look more natural (see Figure 3.7).

Pictures of the untreated control section were taken. It still had a solid gray concrete fabricated appearance (see Figure 3.8). Comparing the one-month-after photo to the 1998 photograph, note that the shotcrete has faded a great deal. The treated section, however, is still more natural looking then the 1998 photograph of the control section.

3.5 THREE YEAR INSPECTION

A final inspection of the desert varnish at Rocky Point was made on October 15, 1998. From the wayfinding point at Port Orford, the shotcrete completely blends into the natural view (see Figure 3.9) As a comparison, you can see the wall and viaduct quite clearly. The north end of the shotcrete, when viewed at close range, shows a variation in the appearance of the desert varnish application. One side looks washed out, while the other remains very dark. The application of the desert varnish on the south end seems more evenly mottled.

The south end of the shotcrete includes a section which is not treated with desert varnish. O.D.O.T.'s Maintenance District 7 repaired an area of broken and cracked shotcrete in May 1998. The shotcrete was not re-sprayed with desert varnish. Note the color contrast in Figure 3.10. The area without the desert varnish is quite distinctly gray and a lip left on the slope is very noticeable.

Figure 3.1: Before Desert Varnish Treatment.

Figure 3.2: One Month after Treatment.

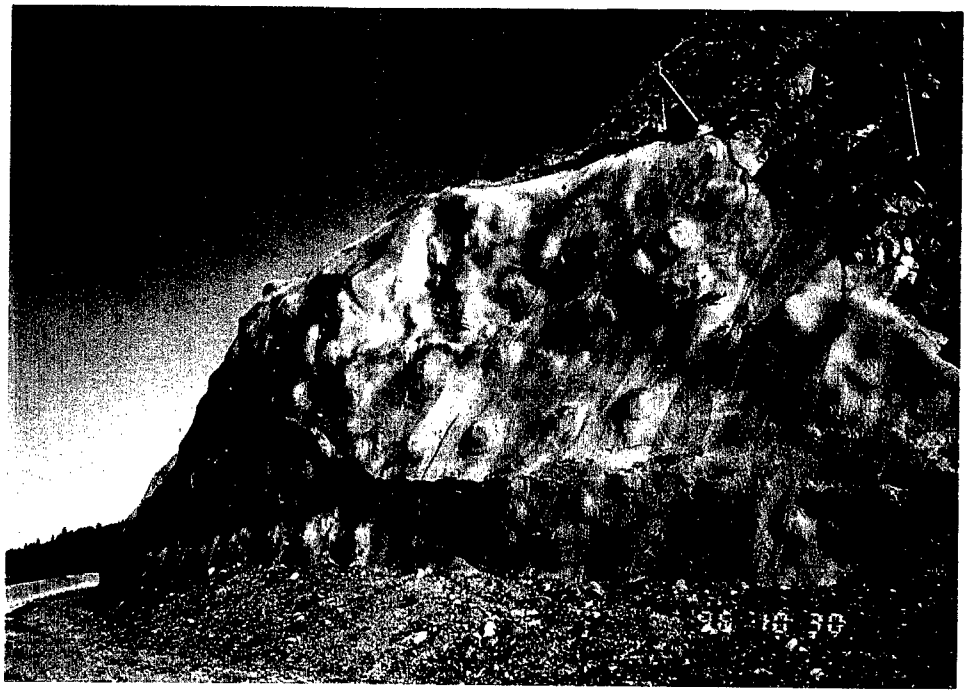

Figure 3.3: One Year after Treatment.

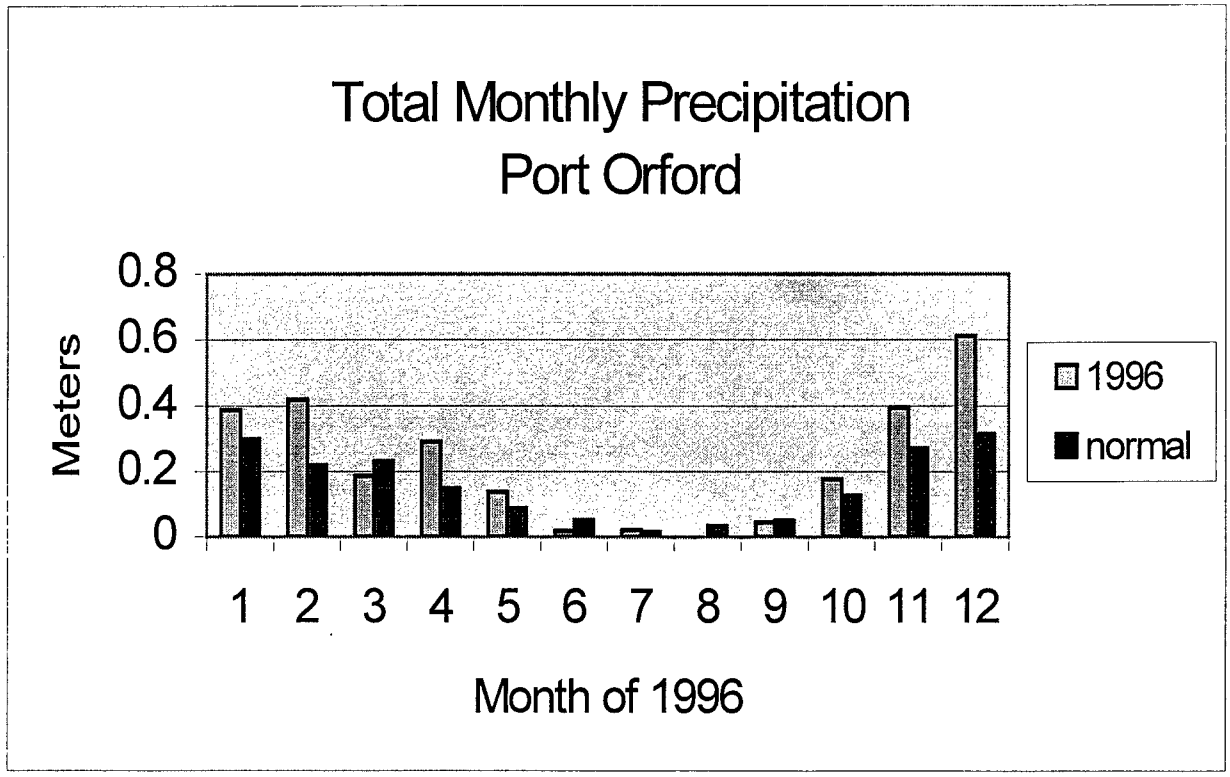

Figure 3.4: 1996 Rainfall in the Port Orford Area.

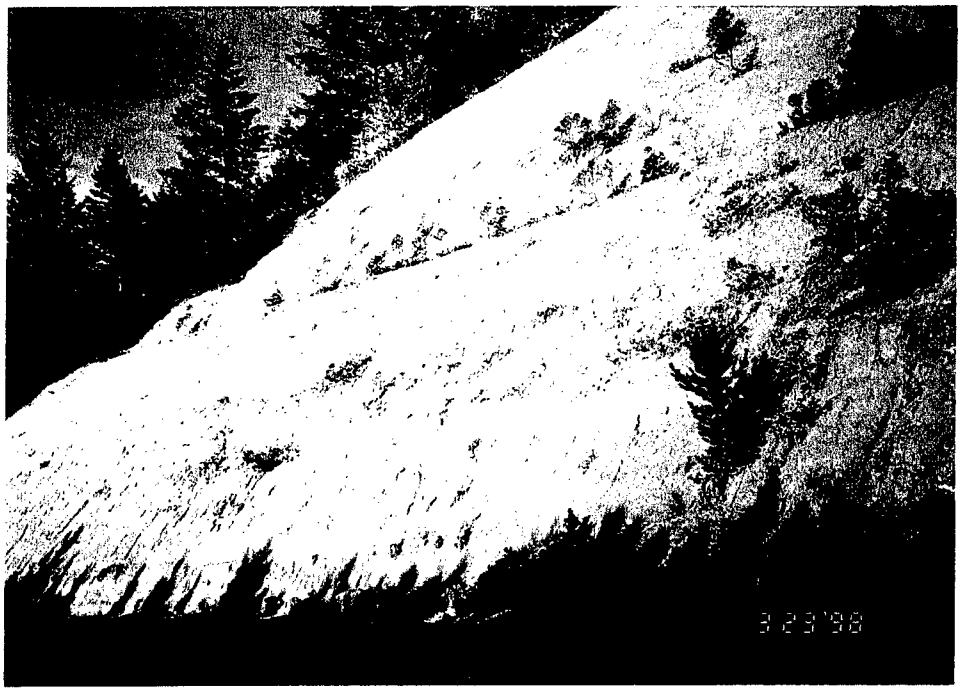

Figure 3.5: Other Slide Banks in the Port Orford Section.

Figure 3.6: Twenty Months after Treatment.

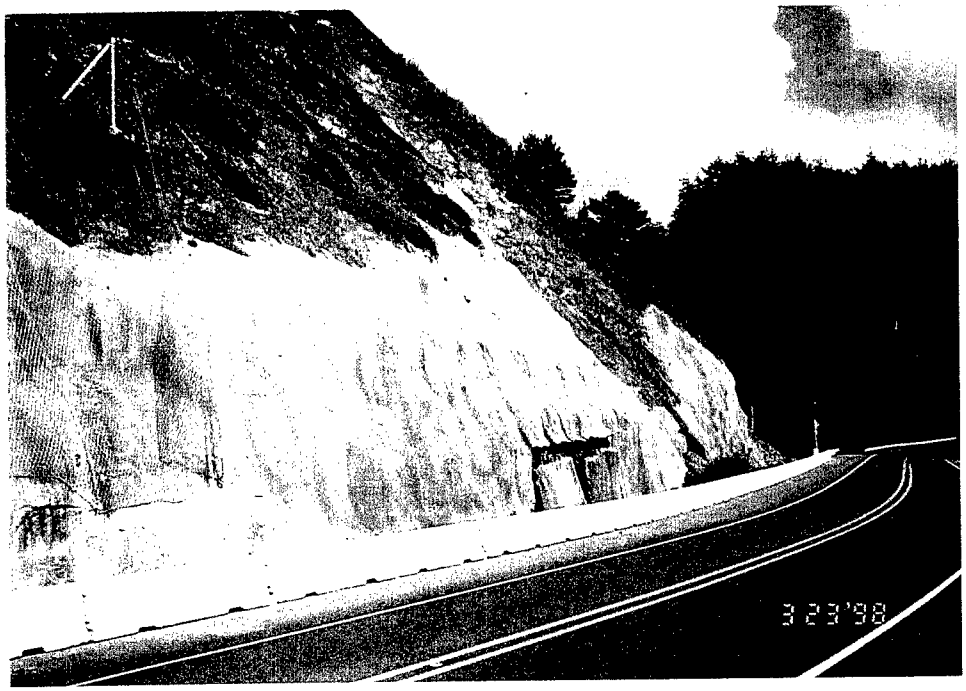

Figure 3.7: Two Years after Construction.

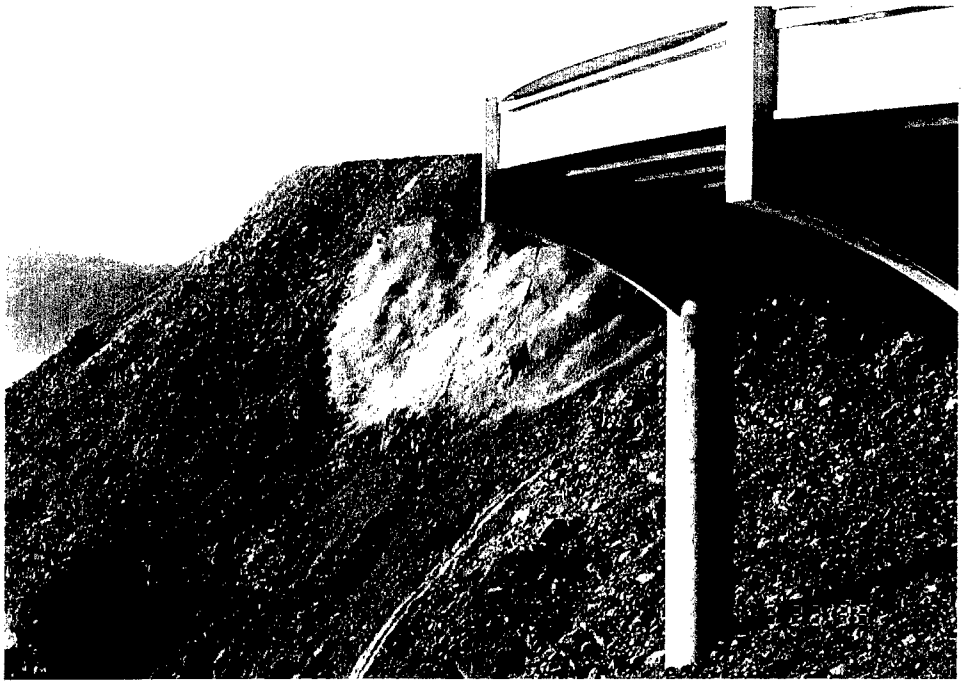

Figure 3.8: Untreated Control Section at North End of the Bridge in 1998.

Figure 3.9: Rocky Point from Port Orford.

Figure 3.10: Three Years: Includes Repaired Area without Desert Varnish.

4.0 CONCLUSIONS

1. The application of desert varnish changed the gray-white shotcrete to a light brown color, mitigating the visible impact of the construction in this scenic area.

2. Over three years, the brown shade has been bleached out by wind and salt spray so that in areas, it now is almost as gray-white as the non-treated section. Mud and rain have streaked the shotcrete face, further blending the project into the surrounding environment.

3. Desert varnish is not a lasting coloring effect near an ocean environment. However, in high visibility areas, it can be effective in minimizing the visual impact of the construction as the natural weathering process occurs.

APPENDIX A

SAMPLE SPECIFICATIONS, STATE OF NEVADA

212.01.01 General. This work shall consist of furnishing and applying rock coloring at the locations specified or established by the Engineer.

212.02.01 General. The rock coloring material shall be a desert varnish material which shall be aqueous solution containing salts of iron and manganese and other trace elements including copper and zinc. The material shall be manufactured as a concentrate that can be diluted with up to six parts water to achieve the desired color intensity. The material shall contain no caustic or alkaline chemicals.

The rock coloring material shall be Permeon or an approved equal. Permeon is available from the following manufacturer:

Advanced Concrete Technologies
11622 Newport Avenue
Santa Ana, California 92705
Phone: (714) 731-0906

212.03.10 Rock Coloring. The rock coloring shall be applied directly to clean rock surfaces. Brown to black colors that develop shall be controlled or modified by custom blending of the basic technique, dilution rate of the color concentrate with water or a combination of these.

The Contractor shall apply the rock coloring to a test section to be reviewed by the Engineer and a representative of the National Park Service. Upon approval of the test section and application procedures by the Engineer, the Contractor may proceed.

The areas to be treated with the rock coloring are all exposed riprap, outlet basins for pipes or reinforced box culverts, and other areas as shown on the plans unless modified by the Engineer.

The rock coloring shall be applied to the back face of the concrete barrier rail at locations and as directed by the Engineer. The concrete surfaces shall be free of curing compounds or other material that may prevent direct contact with the concrete.

212.04.01 Measurement. The quantity of "Rock Coloring" measured for payment will be the number of square yards of treated area as specified herein. Measurement shall be on the plane projection along the exposed planes of the riprap pads and basins. The quantity shown on the estimate shall be considered correct and no additional measurement will be made; however, plus or minus quantities covered by approved changes will be included.

212.05.01 Payment. The accepted quantities of "Rock Coloring" measured as provided above will be paid for at the contract unit price bid per square yard which price shall be considered full compensation for all labor, materials, equipment, tools, supplies and incidentals necessary to complete the work specified herein and as directed by the Engineer.

State of Nevada