Research Report

EXPERIMENTAL APPLICATIONS OF PROTECTIVE COATINGS
TO SHALES EXPOSED IN HIGHWAY CUTS

by
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INTRODUCTION

Many shales exposed in roadway cut-sections are susceptible to weathering, slaking, and erosion; fallout and taluses clog drainage; benches overflow; and occasionally landslides or rockslides develop. Presently, in design, certain types of shales and even named formations are afforded wider benches than others; soil mantles at the tops of cuts are being stripped back farther; and, of course, sound ledge-rock offers the preferred type of bench-cap. Pre-splitting methods of blasting have greatly enhanced the appearance of cuts and have minimized the shattering of cut faces. The resulting surfaces frequently are quite smooth when first exposed and remain so if the materials are resistant to weathering and erosion. However, erosive shales interbedded between sound rock ledges may eventually cause trouble.

Shales, by definition, are consolidated deposits which disintegrate in the presence of moisture and air; some slake readily when immersed in water; others disintegrate slowly when subjected to wetting and drying. The latter phenomenon has led to the use of the term "air-slaking" when immersion alone does not cause deterioration. Freezing and thawing undoubtedly hastens decay. In any case, the decay products are largely clay.

If it were possible to coat the exposed surfaces and so to insulate the shales from air and moisture—to the same degree as that provided by the earth materials before they were excavated—the decay might be arrested or minimized. This inviting notion inspired the experiments described in this report.
PREVIOUS DEVELOPMENTS

During construction of the Summersville Dam, by the Corp of Engineers, on the Gauley River, in West Virginia, in 1960, a diversion tunnel was cut through shale. The portal faces were coated with Aerospray 52, an emulsified polyester resin, manufactured by the American Cyanamid Company. Rock bolts and wire fabric were also used to protect workmen at the portal below from fallout from above. Figure 1 shows the exit portal during construction. Figure 2 shows the same area as of May 11, 1967. The portal itself is now obscured by the roadway. Significant differences between the coated and uncoated areas are apparent.

Likewise, in the construction of the Fishtrap Dam, in Pike County, Kentucky, the Corp of Engineers specified similar protective treatment for extensive areas of shale—the following is excerpted from their specifications.
3-09. Protection of shale surfaces.

a. General. Shales which will be permanently exposed in the spillway or against which concrete will be placed are subject to deterioration by slaking when exposed to air. When directed by the Contracting Officer, exposed surfaces which are subject to deterioration shall be given special treatment to preserve their original moisture content and to protect them from deterioration.

b. Treatment methods.

(1) Initial treatment upon exposure. Each surface designated by the Contracting Officer to receive treatment shall be protected as soon as possible after exposure, and treatment or protection shall be applied before evidences of air slaking becomes visible. Foundation surfaces for concrete structures, and shales which show evidences of air slaking before the protective sealer can be applied, shall be kept continuously wet until the protective sealer is applied.

(2) Subsequent or optional treatments for concrete structure foundations. Where a continuous water spray would interfere with concrete placement operations or would otherwise be impractical at the option of the Contractor, protection shall be accomplished by removing the last 2 feet or more of rock above or against which concrete is to be placed, just ahead of foundation preparation and placement of concrete, or by the use of at least 2-foot thickness of pit run gravel or similar material. Protection by one coat of the protective sealer hereinafter specified for application to permanently exposed surfaces, will also be an acceptable optional treatment. No separate payment will be made for the protective treatment of shale surfaces upon or against which concrete structures will be placed, the costs thereof being included in the contract price per cubic yard for concrete placed against the surface.

(3) Treatment for permanently exposed shale surfaces. Permanently exposed shale surfaces shall be protected with 2 coats of a protective sealer. The sealer shall be "Aerospray 52 Binder", as manufactured by the American Cyanamid Company, Bridgeville, Pennsylvania, or equal. The sealer shall be applied full strength (46% to 48% solids). The sealer shall be applied at the quantity rate and in the manner which the Contracting Officer determines will best protect the surfaces. The Contracting Officer may require the application of additional coats during, or just before, completion of the contract work, so that the seal will be intact at completion of the contract work.
EXPERIMENTAL APPLICATIONS TO HIGHWAY CUTS

On the basis of the previous developments mentioned and favorable observations at the two dam sites, an experimental or trial application of Aerospray 52 and various other coatings was undertaken on a highway cut in the vicinity of Lost Creek on KY 15, in Breathitt County. The cut selected was approximately 237 feet high and was between Stations 1827+00 and 1836+50, on APD 102(46), Subsection AP-13-107-L0CL, and was being excavated when the site was chosen. It was decided, however, that the application of the coatings would be made after the excavation was complete--rather than concurrently. This scheduling proved to be somewhat unfortunate in some respects--as will become evident subsequently. On the other hand, it did not seem appropriate to burden the grading contractor with a belated experimental chore which might prove to be infeasible. Thus, a separate project was authorized; special provisions were drafted; and bids were taken August 25, 1967. Crest Asphalt Company completed the work October 16, 1967. Copies of the Project Authorization and Special Notes are attached hereto as Appendix I. Also, a schematic plan diagram is shown in Figure 3.

Figure 4 shows a portion of the cut as it appeared in April 1967.

Figure 5 and Figure 6 show the cut prior to cleaning and application of the coatings.

Although the Aerospray 52 was of principal interest in the experiment and was granted the largest and most prominent area on the cut face, other types of coatings—as shown in Figure 3—were specified for trial and comparison.
SCHEMATIC DRAWING OF SITE FOR EXPERIMENTAL APPLICATIONS OF COATINGS TO PROTECT EXPOSED SHALES

List of Materials and Area Designations

Area 1: Aerospray 52 - 6000 sq. yds.
Area 2: Linseed Oil Protective Coating - 300 sq. yds.
Area 3: Polystyrene, Styrene - Butadiene - 300 sq. yds.
Area 4: Chlorinated Rubber, Plastciized Lacquer - 300 sq. yds.

CUT SLOPE, RIGHT
SP-13-107
Referenced to: ((APD 102(46), Subsection AP-13-107-10Cl))

Figure 3
PERFORMANCE

Comparison between Figure 4 and Figure 6 shows that considerable weathering of the shales had occurred between the time they were exposed—between early spring and early fall—and the time when cleaning began. The depth of weathering was such that complete removal of the weathered mantle was impractical; instead, the surfaces were raked down with garden tools and swept with a compressed-air jet; even so, they remained rough, fractured and deliminated. This condition constituted a severe disadvantage in the application of the coatings and also to their performance.

Figure 7 shows the treated areas and the cleaned-but-untreated areas between them (October 18, 1968) soon after the applications were completed. The "run down" appearing at the bottom of Area 1 resulted from an extra-heavy application of the Areospray 52. Rock ledges exceeding 18 inches in thickness were to be exempted, and so the massive sandstones at the base of the cut and above the third bench were not coated. Twenty-three barrels of Aerospray 52 were furnished and applied. The percentages of solids in the respective coating materials were:

1. Aerospray 52  46.05
2. Linseed Oil Soln.  57.83
3. Styrene-Butadiene Soln.  23.08
4. Chlorinated Rubber Varnish  39.96

Figure 8 shows a closer view of Areas 2, 3, and 4 taken July 2, 1968.

Figure 9 shows the major portion of Area 1, July 2, 1968.

Figure 10 is a closer view of a portion of Area 1 (Aerospray 52), taken from the second bench, showing loosening and loss of coating.

Figure 11 shows the first bench of the area coated with Aerospray 52, July 2, 1968. The foreground area had been cleaned but was untreated. Some
weeds were growing where water was ponded. Cracks were visible in the coating. The untreated area in the foreground was soft and mushy.

Figure 12 shows the first and second bench, July 2, 1968. The cracks in the first bench below (Aerospray 52) are more visible. Areas 2, 3, and 4 are practically indistinguishable from the untreated area. The "fallout" showing on the second bench obscures the bench coatings.
OTHER EXPERIMENTS

Prior to the larger experiment, a small area in a shale cut at Station 1171+50 on the Mountain Parkway (just west of the Stanton exit, south side) was cleaned and other coating materials of some interest were applied July 14, 1967. The shale there was a different type than that where the Aerospray 52 was to be applied. These coatings were:

1. Dow Latex 460
2. Rohm-Haas Acryloid B-67 MT
3. Watco, Concrete Sealer
4. Linseed Oil (5% mineral spirits)
5. SS-1h (asphalt emulsion, diluted 50%)

They were applied with a brush. The rate of application was not determined. Figure 13 shows the area as it appeared September 11, 1967.

Figure 14 shows the same area, July 2, 1968. The coated areas are indistinguishable and no evidence of the coatings or any effects from them is apparent. Evidently the coating vanished during the winter and early spring.

On December 5, 1967, two small swathes (12 feet high by 14 feet wide) (second bench) within the untreated area to the SF-13-107-12 site were coated with:

1. SS-1h, asphalt emulsion, diluted 50%
2. Acryloid B-67 MT, 50% mineral spirits

Figure 15 shows the two swathes immediately after coating. The coatings were also applied with a brush and in quantity to satisfy imbibition.
SUMMARY AND RECOMMENDATIONS

In these experiments, none of the coatings produced the desired effects. Minor differences in the amount of "fallout" accumulated on the benches are apparent. Some erosion of the soil mantle at the summit of the cut has compounded the accumulation of material on the upper benches.

It seems altogether evident that a higher degree of success than that achieved in these trials would have to be demonstrated before the protective coatings could be considered to be feasible for use in highway cuts. It seems equally evident that the most opportune time to apply coatings is when the shales are first exposed.

These conclusions were anticipated by others and were so recorded in an intra-Department memorandum report (see Appendix II).

In view of the apparent success achieved by the Corp of Engineers in the use of the Aerospray 52, these trials merely confirm the impracticality of treating shales after the onset of weathering and slaking. Thus, the principal objective remains to be demonstrated. Further experiments directed toward application to fresh exposures seem warranted. It may be noted that the Corp of Engineer's specifications for the Fishtrap Dam state that shales "...shall be kept continuously wet until the protective sealer is applied."
APPENDIX I

1. Project Authorization
2. Special Notes for Application of Protective Coatings...
It is hereby ordered that the project described herein be undertaken and accomplished.

PROJECT IDENTIFICATION

1. District 10
   County Breathitt
   Route Number KY 15
   Project Control Number SP-13-107

2. Road System FAP
   Road Name Jackson-Hazard

3. Project Description and Type of Work
   Applications of coatings to protect shale cuts from deterioration and erosion; cut slope, Sta. 1827+00 to Sta 1836+50, right of centerline, Stations referenced to APD 102(46), Subsection AP-13-107-10C1

4. Design Class N.A.
   Traffic Present - N.A.
   Projected - N.A.
   Project Length 0.18 Mile

RESPONSIBILITIES

5. Design Right of Way
   None Required
   No Additional Required
   Title Deeded To Ky. Dept. of Highways

6. Utility Construction
   None Required
   Dept. of Highways (Contract)
   Maintenance Ky. Dept. of Highways (MP)

SOURCE OF FUNDS AND ESTIMATED COST

7. Design Estimated Cost
   None Required
   Account Number
   Fiscal Year

8. Right of Way Estimated Cost
   None Required
   Account Number
   Fiscal Year

9. Utilities Estimated Cost
   None Required
   Account Number
   Fiscal Year

10. Construction Estimated Cost
    Dept. of Highways $19,250.00
    Account Number 210
    Fiscal Year 67-68

11. Total Estimated Cost
    $19,250.00
    Project Completion Date
    (month and year)

12. Remarks: Some shales exposed in roadway cut sections are susceptible to weathering, slaking, and erosions; fall-out and taluses clog drainage and otherwise imperil the roadway. Aerospray 52, a poly-ester resin manufactured by the American Cyanamid Co., has been used successfully for this purpose by the Corps of Engineers in dam construction. It is recommended that the Department undertake a trial application of the coating and establish an experimental installation at the subject site. It is proposed to contract for 6,000 sq. yds. of the Aerospray 52 protection and 300 sq. yds. each of three other coating materials to be specified. Comparative performance and evaluations will be made by the Division of Research.

PROJECT APPROVAL RECOMMENDED BY

Director of Research

SIGNED AND APPROVED

Commissioner of Highways or Designated Representative

Date 7-21 1967
SPECIAL NOTES
FOR
APPLICATIONS OF PROTECTIVE
COATINGS TO SHALES EXPOSED IN CUT SLOPES
(Experimental)

KY 15, Breathitt County, Jackson-Hazard Road

SP 13-107
Sta. 1827+00 to Sta. 1836+50
Stations referenced to APD 102(46)
Subsection AP 13-107-10Cl

I. DESCRIPTION

Shales which are exposed in roadway cut-sections and which are susceptible to weathering, slaking, and erosion cause fallout and taluses which clog drainage and otherwise imperil the roadway. These notes describe the application of coatings which are intended to prevent or arrest disintegration.

II. CLEANING

All loose, weathered, unsound material shall be removed by hand and tools and disposed of as directed by the Engineer. All surfaces designated for coating shall be cleaned and dried with air jets prior to applying the coating.

III. COATING MATERIALS

The coating materials shall consist of the following, designated products:

1. Aerospray 52; a liquid, sprayable, polyester resin solution manufactured by the American Cyanamid Company and certified to be nominally the same product as used by the Corp of Engineers in connection with the construction of Summersville Dam in West Virginia and the Fishtrap Dam in eastern Kentucky.

2. Linseed Oil Protective Coating*

*A mixture compounded, by volume, to contain:

Boiled Linseed Oil (AASHO Specification M 126) 50%
Mineral Spirits (AASHO Specification M 128) 50%
3. Styrene-Butadiene or Polystyrene Solution*

*Clear Bond, manufactured by the Guardian Chemical Company, 708 Jefferson Street N. W., Atlanta, Georgia

or

56-E-2, Concrete Penetrant and Hardener, manufactured by George W. Whitesides Company, Thirty-First and Michigan Drive, Louisville, Kentucky.

4. Chlorinated Rubber, Plasticized Lacquer; compounded as follows:

<table>
<thead>
<tr>
<th>Solids, 25%</th>
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<tbody>
<tr>
<td>Parlon S 10 (Hercules Powder Company)</td>
<td>50%</td>
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<tr>
<td>Aroclor 5460 (Monsanto Chemical Company)</td>
<td>20%</td>
</tr>
<tr>
<td>Clorafin (40%)(Hercules Powder Company)</td>
<td>30%</td>
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<tr>
<th>Solvent, 75%</th>
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<tr>
<td>Toluene (TT-T-548, Technical)</td>
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<tr>
<td>V. M. &amp; P. Naphtha (TT-N-95a, Type II)</td>
<td>19%</td>
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<tr>
<td>Pine Oil (Yarmor 302, Hercules Powder Company)</td>
<td>5%</td>
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IV. APPLICATION

Coatings shall be applied by spray and to the respectively designated areas. Two coats shall be required; the primer coats shall be allowed to dry to a tack-free condition before the second coat is applied. The second coat shall be applied before dust and debris contaminate the primed areas.

Each coat shall be applied undiluted and at the maximum feasible quantity per unit of area—covering not more than 25 square yards nor less than 5 square yards per gallon, and the material shall be deployed according to the absorptivity of the surface—taking care to avoid excesses as well as too-sparing applications. Rock ledges having uniformly sound quality and hardness and exceeding 18 inches in nominal thickness shall not be coated. No application shall be made between November 15 and May 30 nor when seepage of ground waters interfere with cleaning and drying of the surface to be coated. The preparations and applications shall not interfere with scheduled construction work consigned to others by prior contracts nor shall this work be commenced before a notice of admittance to the site or order to begin work is furnished by the Engineer.
V. ACCEPTANCE OF MATERIALS

No materials shall be applied before notice of acceptance has been furnished by the Department's Division of Research. Acceptance may be made on the basis of certification of compliance by the manufacturer to the contractor, copies of which shall be submitted to the Department, or on the basis of sampling and testing of materials delivered to the job site—as the Department may elect.

VI. BASIS OF PAYMENT

The units of measurement for payment shall be square yards of net surface satisfactorily prepared and coated. The net area multiplied by the bid price shall constitute all due compensation for materials, labor, and incidental costs. The respective, designated coatings shall be bid separately and individually. Drawings attached to and made a part hereof shall govern in the absence of other plans and specifications.
List of Materials and Area Designations

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Area 3: Polystyrene, Styrene - Butadiene - 300 sq. yds.
Area 4: Chlorinated Rubber, Plasticized Lacquer - 300 sq. yds.

SCHEMATIC DRAWING OF SITE FOR EXPERIMENTAL APPLICATIONS OF COATINGS TO PROTECT EXPOSED SHALES

Referenced to: (APD 102(46), Subsection AP-13-107-10C1)
APPENDIX II

INTRA-DEPARTMENT MEMORANDUM REPORT
November 14, 1967
MEMORANDUM

TO: James H. Havens, Director
Division of Research

FROM: K. B. Johns
Operations Management Engineer

SUBJECT: Aerospray 52 Experimental Project
Breathitt County KY 15

I am attaching a report of observations by G. W. Asbury and L. E. Richardson regarding the subject project. You may find this of interest, and we look forward to your findings relative to the effectiveness of this experimental work.

KBJ:vbn
cc: W. B. Drake
T. J. Hopgood
A. O. Neiser

Attachment:
MEMORANDUM

TO: K. B. Johns, Operations Management Engineer
FROM: L. E. Richardson, Maintenance Engineer Principal
G. W. Asbury, Assistant to the Operations Management Engineer

SUBJECT: Aerospray 52 Experimental Project
Breathitt County KY 15

In compliance with your request we have followed the progress of the subject project. Our consideration has been primarily directed toward the application related to present maintenance problem areas and the feasibility of application by state forces. We assume that the Division of Research will report on the actual performance of the material.

Based on our observations and conversations with District Construction personnel we have concluded that the most economical, and possibly the only feasible, approach to the usage of this material would be to include this item as incidental to excavation and make it a responsibility of the prime contractor. We reached this conclusion since all concerned apparently agree that the earliest possible application is the cheapest and has the best chance of success. It is our opinion that on the subject project the time lag between excavation and the application of Aerospray 52 was too great.

The above conclusion neatly solves the two considerations that we intended to explore for all future construction projects. In general it does not seem practical to use the subject material on old cut slopes. Some unusual situations may occur whereby where this treatment may represent a feasible approach to eliminate extremely costly maintenance problems. If this were the case, application by state forces could be accomplished from an operational standpoint. The availability of personnel would be the major criteria since the techniques involved aren't highly technical and do not
require any particular training. In summation we would suggest that if the
Division of Research report concludes that the subject material is a feasible
method of protecting slopes; the application be included as a responsibility
of the prime contractor. We would not recommend the use of this material
on weathered slopes.

GWA: it