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Department of the Interior
Bureau of Reclamation

OPERATION AND MAINTENANCE EQUIPMENT AND PROCEDURES

RELEASE NO. 18

October, November and December 1956

CONTENTS

OPERATION AND MAINTENANCE

EQUIPMENT AND PROCEDURES

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INTRODUCTION

Concrete, for the most part, has given excellent service over the years as a canal lining material. Some concrete linings have been in service for 40 to 50 years. Advances in concrete construction techniques and the use of air entrained concrete should provide even better service in the years to come. However, as would be expected from long periods of exposure, some disintegration and deterioration does occur, especially in concrete surfaces that are constantly exposed to erosion, scour and weather. Accordingly, some of the older concrete linings are now in need of repair. This issue of the Bulletin is devoted to the experimental repair of concrete linings, and the record of durability of such repair, in an effort to prolong their servicable lives. Future Bulletins will present other methods of repairing canal linings and reports of the service obtained from these repairs.

This Bulletin, published quarterly, is circulated for the benefit of irrigation project operation and maintenance people. Its principal purpose is to serve as a medium of exchanging operation and maintenance information. Reference to a trade name does not constitute the endorsement of a particular product, and omission of any commercially available item does not imply discrimination against any manufacturer. It is hoped that labor-saving devices or less costly equipment developed by the resourceful water users will be a step toward commercial development of equipment for use on irrigation projects in continued effort to reduce costs and increase operating efficiency.

Error corrected: (pen and ink changes)

In Release No. 16, a Table of Contents was prepared and various articles from previous issues were reprinted so that those who wished to could consolidate all items published on weed control into one volume. We're sorry, but we overlooked three articles in Release No. 9. The page numbers appearing on the articles as originally released should be changed as follows: Weed Burner (Oil) . . . IA15, sheets 1 and 2; Moss Screens . . . IB9, sheets 1 and 2; Weed Cutting Launches . . . IIB13, sheets 1 through 4. The foregoing three articles should be added to the Table of Contents in Release No. 16 to make it complete. Also the Table of Contents should be corrected to show that articles appear in Release No. 9 as well as Releases No. 3 and 8. To follow the key already established, three asterisks (***) are suggested to designate Release No. 9 articles.

* * * * *

Division of Irrigation Operations

Comissioner's Office
Denver, Colorado.

RESURFACING DETERIORATED CONCRETE LININGS

Rehabilitation of portland cement concrete linings has been one of the many problems facing operation and maintenance personnel on our irrigation projects over the years. In the attempt to keep our canals in service, various materials have been used to rehabilitate and resurface the concrete linings. To briefly evaluate some of the methods and materials used in resurfacing, so far as durability and performance are concerned, there is being summarized herein the results of inspections made on the Boise Project in Idaho.

The rehabilitation of deteriorating or aging linings was reviewed primarily in an effort to guide repairs to be made on the canals of the Boise Project and the Kittitas Division of the Yakima Project, Washington. The condition of the existing lining and the subgrade, and the conditions under which the canal must be operated will govern the repairs that can be made.

Main Canal - Boise Project

Asphaltic Concrete

One of the early uses of asphaltic concrete for the purpose of rehabilitating portland cement concrete, is an installation made on the Boise Project in Idaho. This installation on the Main Canal (formerly the New York Canal) was made in 1944 with the placement of approximately 7,200 square yards of a $1\frac{1}{2}$-inch thick asphaltic concrete mat over the badly eroded concrete lining which had been in service since 1909 and 1910. Inspected and tested in 1955, the asphalt "half-sole" was still in good condition after having been in service for 11 years.

The canal was originally constructed by a private canal company beginning about 1895. In 1906, the canal was transferred to the Reclamation Service, the forerunner of the Bureau of Reclamation, and it was enlarged and extended in 1906 and 1908. At the conclusion of this work, the canal had a bottom width of 40 feet, but provision had been made for future development to a bottom width of 70 feet.

From the diversion point to approximately Mile 10, the canal is in sidehill location and is excavated through a gravelly soil. To insure the safety of the canal and prevent seepage, eleven sections totaling 5.8 miles in length within the first 10 miles were lined with concrete in 1909 and 1910. In several of these sections, the lining covers only the lower bank, or the lower bank and the right half of the bottom. From 1909 and 1912, the earth sections between the lined section and the remainder of the canal below the last lined section were enlarged to a base width of 70 feet.

Since 1910, additional concrete lining has been constructed and most of the lining installed in 1909 and 1910 has been replaced or resurfaced so that much of it is now 8 inches thick. The canal conveys approximately 3,000 cfs of water at a velocity of approximately 6 to 7 feet per second. With a high sand load the bottom has been eroded and scoured.

In 1926, operation of the canal was transferred from the Bureau of Reclamation to the Boise Board of Control, an agency composed of representatives of the several water user organizations which receive water from the canal. During April and November 1944, approximately 7,200 square yards of badly eroded portland cement concrete lining in the bottom of the canal were rehabilitated by placing a $1\frac{1}{2}$-inch thick asphaltic concrete mat over the old concrete lining.

Construction

The $1\frac{1}{2}$-inch thick asphaltic concrete mat was laid over the old concrete in one layer. Before the mat was placed, the surface of the old lining was cleaned with a rotary brush, primed with kerosene, and given a tack coat of hot 50-60 penetration asphalt. The work was accomplished by contract.

The resurfacing material consisting of 10-percent asphalt of 50-60 penetration and aggregate was hot mixed in the contractor's plant in Boise. The hot mix was transported by truck to the site of placement where it was dumped on the old concrete lining ahead of and spread by a paver, photographs at left.

The temperature of the mix delivered to the site of the work was around 300° F. Most of the lining was later sealed with an application of hot asphalt of the same grade used in the mix.

As shown in the photograph at the top of the following page, the lining was rolled with a 12-ton standard roller, no particular trouble being experienced, other than that it was usually necessary to wait for some cooling before rolling.

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The total cost of resurfacing by contract in 1944 was reported to be $1.27 per square yard for the 1½-inch thick mat of asphaltic concrete.

Performance

In September 1944, an inspection of the lining constructed in April 1944, revealed that the upstream edge of the asphaltic concrete had separated from the old portland cement concrete and several square yards of the asphaltic lining had floated away. To prevent further damage and to complete rehabilitation of the old lining, the asphaltic concrete lining was extended upstream to the end of the old concrete lining and secured with a cut-off wall. Constructed at the end of and adjacent to the old concrete lining, the cut-off wall consisted of a 12-inch wide trench 36 inches deep filled with asphaltic concrete. The asphaltic concrete was compacted in the trench by hand tamping.

The September 1944 inspection also revealed some slight erosion on the surface of the lining which had not been sealed. Generally, however, the lining was in excellent condition after one season of operation.

An inspection in April 1952, after 8 years of service, photograph below, revealed little change in the general condition of the lining. Close examination of several representative areas, photograph at top of the following page, showed little, if any, erosion and no deleterious effects from mud curling. Bond between the portland cement concrete and the asphaltic concrete appeared to be excellent throughout the length of the repaired sections. The Manager of the Board of Control reported in 1952 that no

fig 3

maintenance has been performed in the sections since they were completed in 1944.

Again inspected during the summer of 1955, as shown in the photographs below and on the following pages, it is in excellent condition after $10\frac{1}{2}$ years of service.

The middle photograph on this page is a general view of the Main Canal looking upstream from approximately Mile 1.

Although there was a thin sheet of water over much of the lining the asphalt mat was discernible and there did not appear to be any evidence of cracks in the older concrete lining being reflected or transmitted through the asphaltic concrete mat.

The lower photograph on this page is a view of the $1\frac{1}{2}$-inch thick asphaltic concrete on the bottom of the canal at approximately mile 2.8 after $10\frac{1}{2}$-years of service. In the photograph at the top of the following page a close up of the asphaltic concrete surface is shown. The surface has been roughened over the intervening $10\frac{1}{2}$ years, but there were few cracks and little errosion was apparent.

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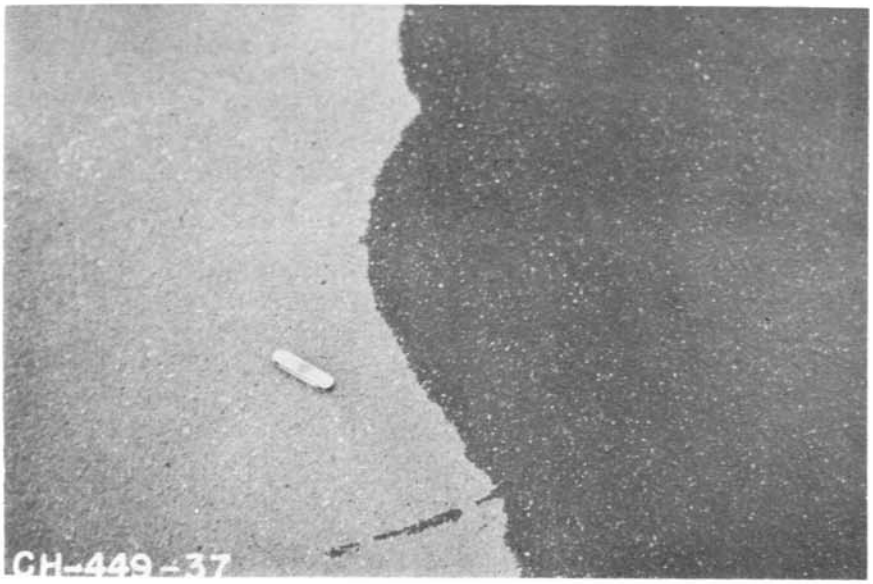

Ridenbaugh Canal

The Ridenbaugh Canal is operated by the Nampa-Meridian Irrigation District, Arrowrock Division, Boise Project, Idaho, to irrigate 27,000 acres of the Boise River Valley lands in the vicinity of Nampa and Meridian, Idaho. The old original canal was probably constructed some time in the 1870's. In 1910-11, a section of the canal 9,200 feet long was lined with a 4-inch unreinforced concrete lining.

The canal as originally lined with portland cement concrete had a capacity of 618 cfs, with a bottom width of 10 feet, a velocity of 5.42 feet per second, and a normal water depth of 6 feet. The 4-inch unreinforced concrete lining was placed on side slopes of $1\frac{1}{2}$:1 and the lining height was 7 feet. Practically all of the concrete lining was still in place when inspected in 1947, however, longitudinal and pattern cracking of the concrete was prevalent in practically every panel. In some panels, the surface had weathered and erosion and disintegration had progressed to varying depths. In places this disintegration had progressed completely through the concrete lining.

The section of deteriorated concrete lining was selected as the site for obtaining information relating to the restoration and rehabilitation of old concrete irrigation canal linings in connection with

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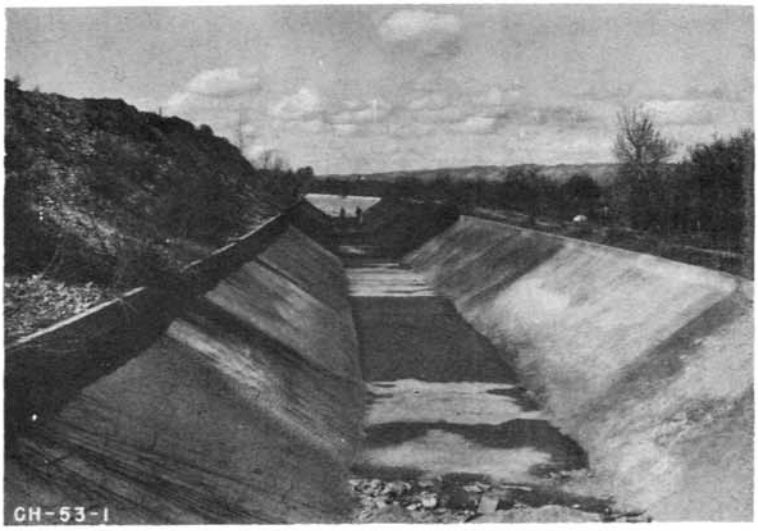
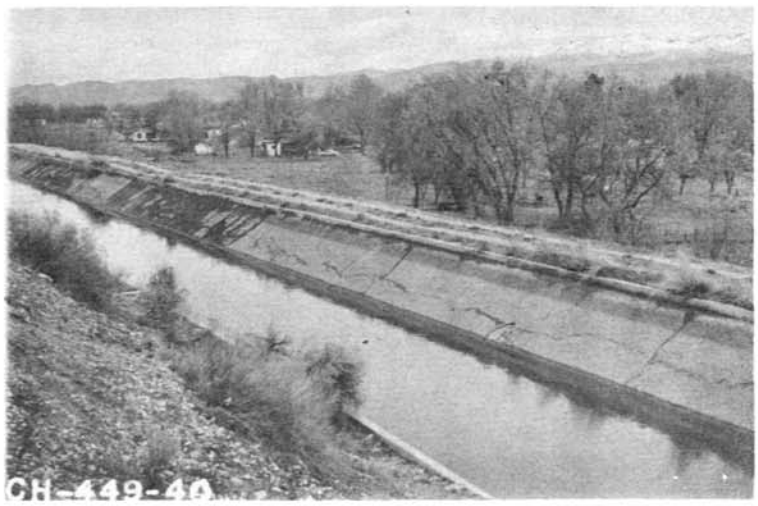
the Bureau of Reclamation's Lower-cost Canal Lining Program. Accordingly, in 1947, several different materials and methods of placing these materials were tried. The various types of resurfacing materials used are described and photographs of the linings at the time of placement in 1947 are compared with photographs of the same materials as they appeared at the time of inspection in 1955, after 8 years of service.

A typical view of a portion of the canal at the time some of the linings had been placed in 1947 is shown in the first photograph below. The old concrete lining in the foreground has been resurfaced with pneumatically applied portland cement mortar. Other resurfacing materials are being applied to the old concrete lining in the background. The lower photograph is a view of a portion of the resurfaced concrete lining after it has been in service for 8 years. Again the pneumatically applied portland cement mortar is shown in the immediate foreground, extending from right to left, with the other resurfacing materials toward the left. Practically all of the experimental resurfacing materials showed some signs of deterioration, with several being so badly weathered or eroded as to be no longer serviceable.





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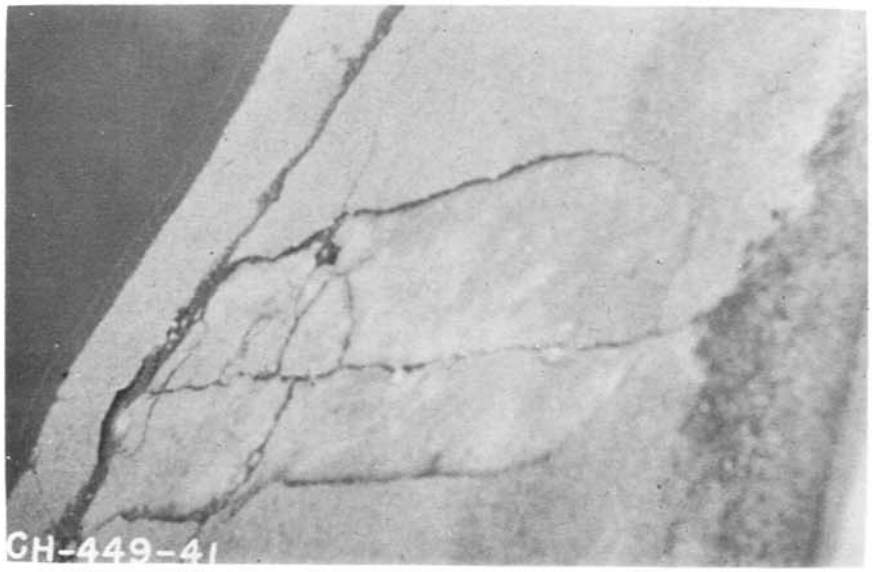
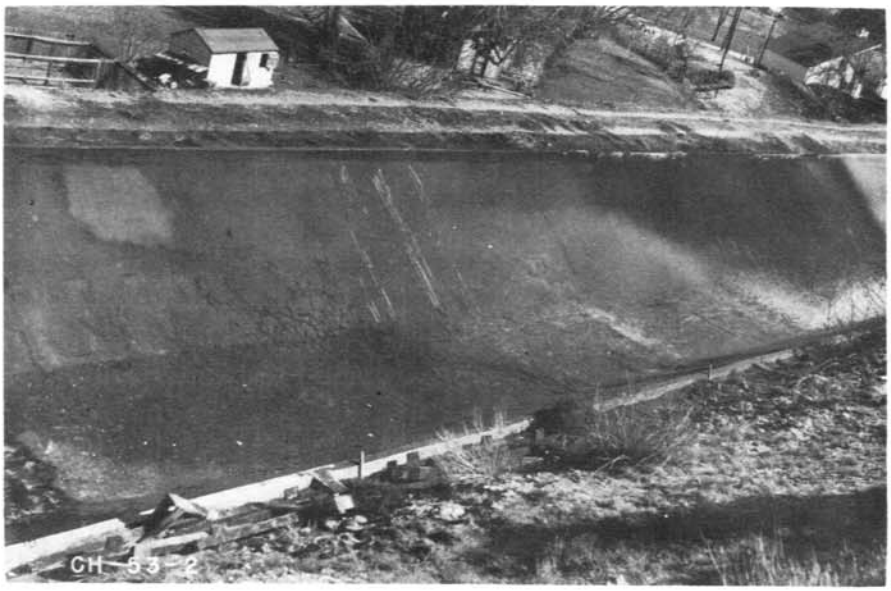
Pneumatically Applied Portland Cement Mortar

The 1½-inch thick pneumatically applied portland cement mortar or shotcrete resurfacing had a very good appearance at the time it was placed, as shown in the upper photograph on the previous page. After 8 years, in addition to the spalling and cracking apparent in the lower photograph on the preceding page and in the photograph at left, the resurfacing material was drummy, with voids apparent between the old portland cement concrete and the resurfacing of portland cement mortar.



Pneumatically Applied Asphalt-sand Mixtures

In the photograph at the bottom of this page are shown two types of asphalt-sand mixtures, also placed pneumatically. The resurfacing material at the left in the photograph is a mixture of asphalt emulsion and sand and that toward the right is a mixture of RC-O cutback asphalt and sand. (The light colored surfacing material at the extreme right in the photograph is a portion of the pneumatically applied portland cement mortar described previously.)

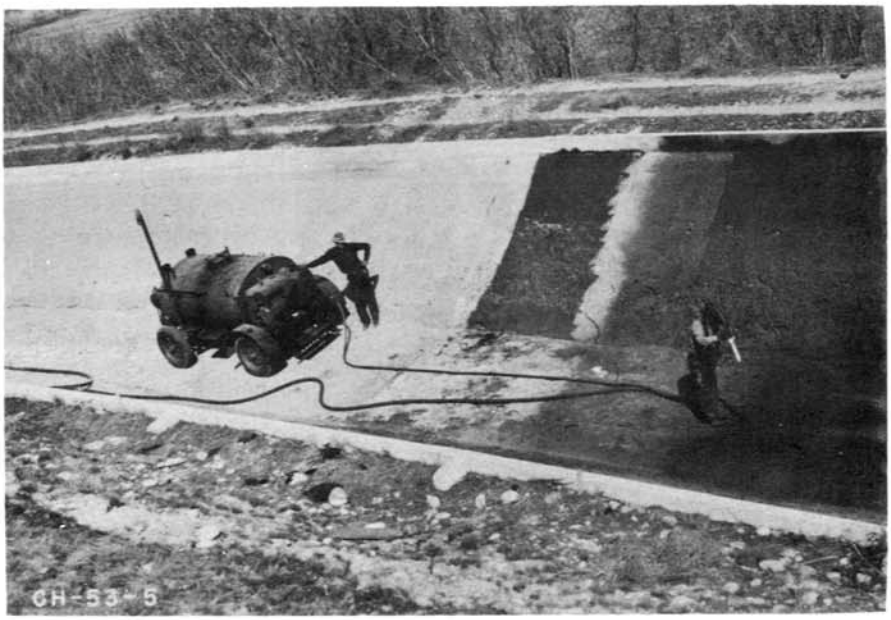


The RC-O asphalt and sand was placed to a minimum thickness of 1/2-inch. It was soft and appeared to have a permeable structure. The softness was considered to be due to the inability of the cut back asphalt to properly cure under this condition of use. The photograph at the top of the following page is a view of this resurfacing material after 8 years of exposure. Large areas of the resurfacing material had

been eroded and that remaining was soft and badly spalled and cracked. This resurfacing material was applied after first applying a tack coat of the same material to the old concrete lining.

The asphalt-emulsion and sand mixture was placed at various thicknesses over the old concrete lining; some, after first treating the old concrete surface with a tack coat of RC-O cut back asphalt, and some, directly to the untreated concrete surface.

The resurfacing, photograph below had a fair appearance at the time of placement except for an exceptionally heavy rebound of sand particles. The rebound was largely uncoated, indicating that the emulsion was not coming into proper contact with the sand in the pneumatic nozzle. Completed sections, when swept clear of the rebound, appeared firm and quite tight, with a fairly smooth surface. The first part of the emulsion-sand was constructed with an RRW asphalt emulsion, using the pneumatic gun shown above. An attempt was made to use an NX, quick breaking emulsion but the emulsion broke in the gun and the material could not be applied. In order to secure a test application of the NX emulsion, it was applied by a spray bar attached to a distributor truck, while the sand was applied with the pneumatic gun, photograph at top of the following page. One man operated the hand spray bar and applied the asphalt, while a second man operated the gun. No difficulty was encountered using this method. The sand, upon striking the emulsion film, broke the emulsion rapidly and there was very little rebound.



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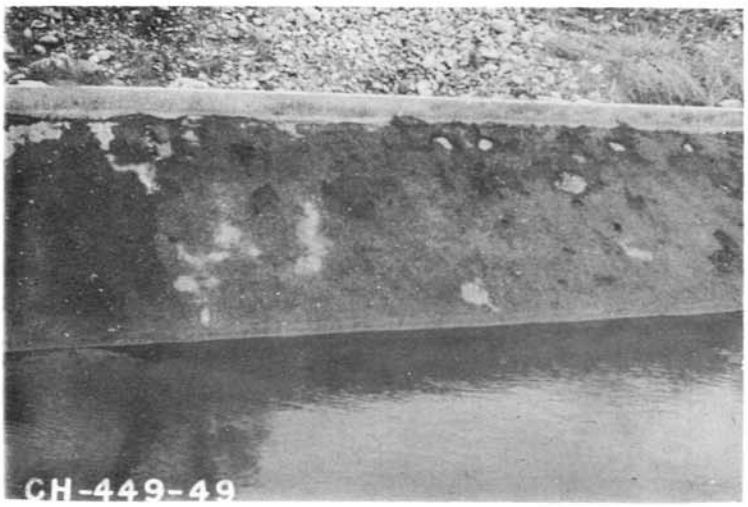
A firm, smooth surface with a good buildup of material over the concrete lining was obtained. Previously tried in the laboratory, with RC- cut-back asphalt and with hot asphalt cement this method produced negative results. The emulsion as used in the canal resurfacing work was very satisfactory.

Views of the asphalt emulsion resurfacing after 8 years of service are shown in the two lower photographs on this page. Severe disintegration and spalling is apparent in the first treatment as shown at left, with total erosion in some areas.



That placed by the simultaneous application by hand spraying the asphalt emulsion and pneumatic application of the sand, is in better condition, as shown in the lower photograph. Although in somewhat better condition than that shown above, it also was badly spalled and cracked and the remaining material was soft.

fig 6

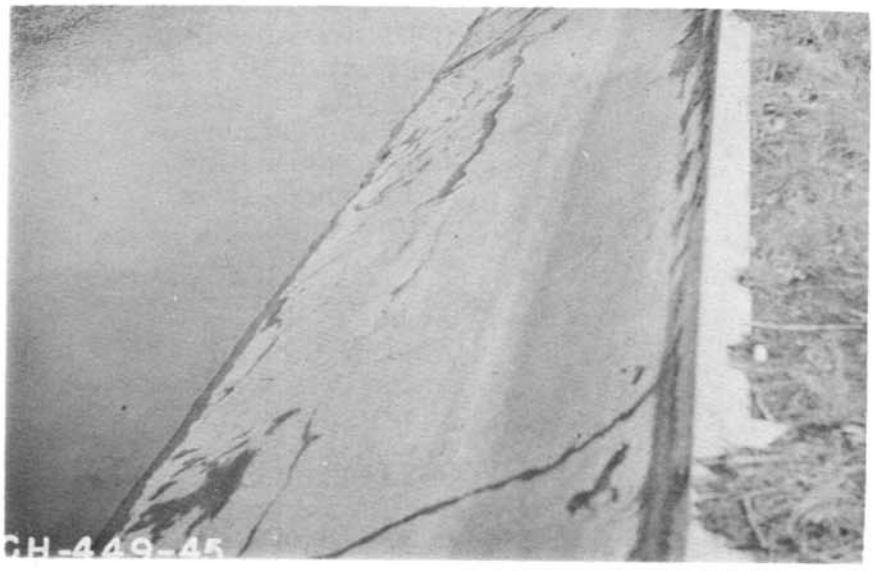
Mineral Filled Asphalts

In the photograph immediately below, a section of the old portland cement concrete lining was resurfaced with a mineral filled asphaltic cement. It was applied as a relatively thin membrane by spray.

The resurfacing was primarily a seal coat and consisted of 23 percent diatomaceous earth and 77 percent, 85-100 penetration asphaltic cement.

The material applied, thoroughly coated and waterproofed the concrete lining, resulting in a slick, tough surface. A part of the section treated was resurfaced by spraying the material directly upon the old concrete surface and the balance was applied after first applying a tack coat of RC-O cutback asphalt to the old concrete.

At the time of placement, this section did not look as good as the pneumatically applied resurfacing material due to the relative thinness of the coating. All rough and eroded areas of the old concrete lining were still visible after the resurfacing had been applied, due to lack of a "build-up" of the more deeply eroded and rough surfaces.



The condition of the thin membrane after 8 years of service is shown in the photograph at left. For practical purposes, the membrane has been eroded from the surface of the old concrete where the surface was not primed with the RC-O cutback asphalt, prior to application of the filled asphalt cement. There is much sagging, curling and erosion apparent where the surface was primed, as shown in the photograph at the top of the following page.

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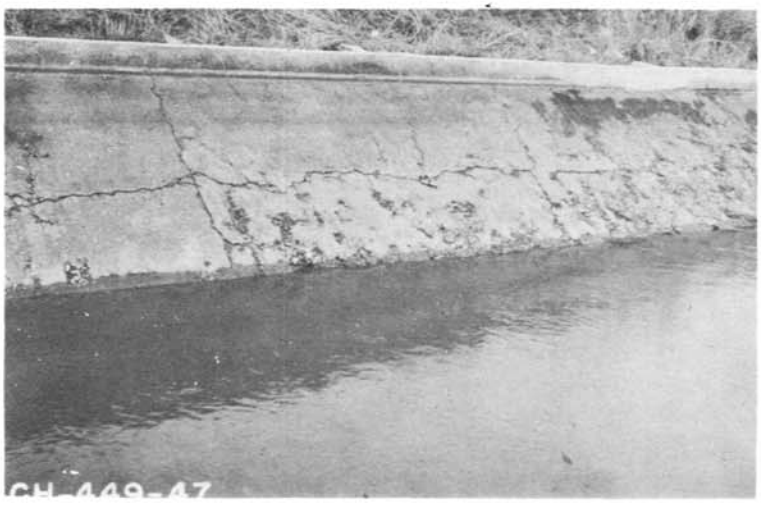


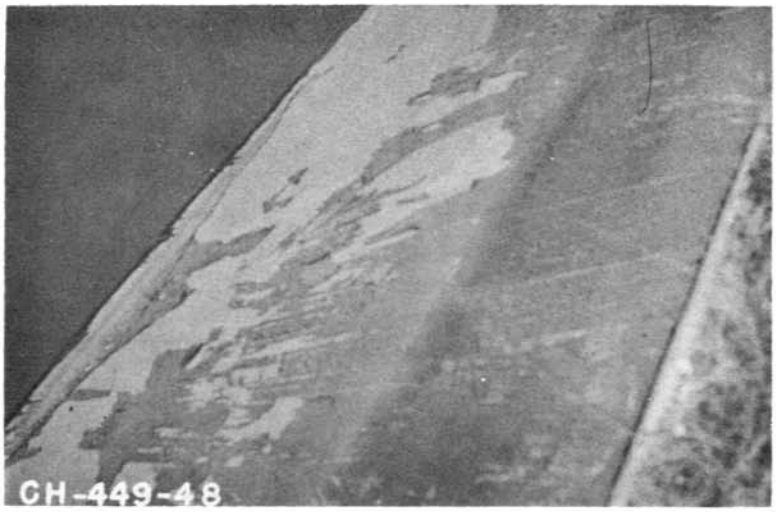
An application procedure, similar to that previously described, was followed in resurfacing a section of concrete lining with a mineral filled asphalt-emulsion, as shown in the middle photograph. The thin seal coat was applied with and without an RC-O cutback asphalt tack coat, and consisted of a soft, 200-penetration, asphalt cement having a 23 percent filler of diatomaceous earth applied at a temperature of 140 degrees F.

A good spray was obtained at the application temperature, and the resulting surface was fairly satisfactory.

As shown in the lower photograph this material also had been badly eroded from the surface of the old concrete lining when inspected in 1955 after 8 years of service.

A "Laykold Weather Coat", also a filled asphaltic-emulsion, was applied to the surface of the old concrete lining by brush. Approximately 50 percent

of the coating had been lost in the 8 years of service, as shown below, and the remaining portion of the filled asphaltic-emulsion was thin, oxidized and brittle.



Coal Tar

In a short reach of the test section, a coal tar waterproofing was placed on the surface of the old concrete lining. The condition of this resurfacing material after 8 years of service and exposure is shown in the photograph below. At least 50 percent of the resurfacing material has been eroded and that remaining is thin, badly oxidized and brittle.

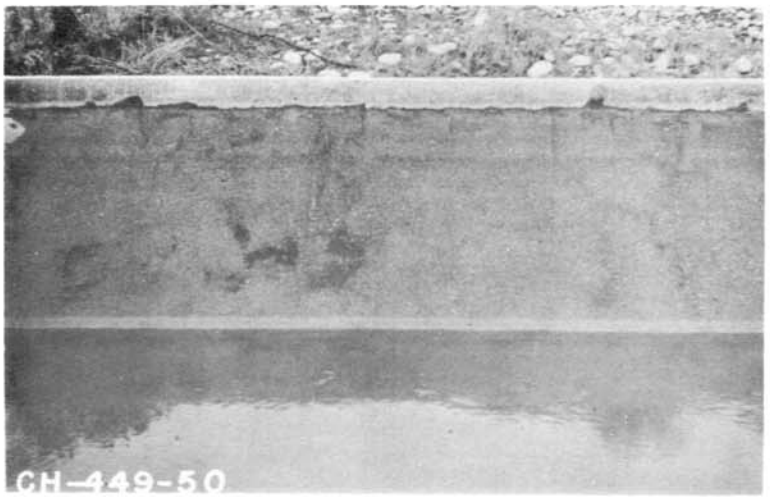
Asphaltic Concretes

Two types of asphaltic concrete were also placed over the disintegrated and weathered concrete lining. Both were placed to a minimum

thickness of 1/2-inch. One was an asphaltic-emulsion concrete and the other an asphaltic-cement concrete, both were "hot-mixed" in a central plant.

The "hot-mix" asphalt-emulsion, shown in the photograph below, was composed of an RX emulsion and a graded aggregate. The aggregate was heated to about 225 degrees F, before adding the emulsion. Eleven percent of emulsion was added, giving the mix an asphalt content of approximately 5.5 percent. Placement and rolling of the asphaltic-emulsion as shown was preceded by the application of a tack coat of RC-O cutback asphalt to the old portland cement concrete lining and hand raking to assure a minimum resurfacing material thickness of 1/2-inch after compaction.

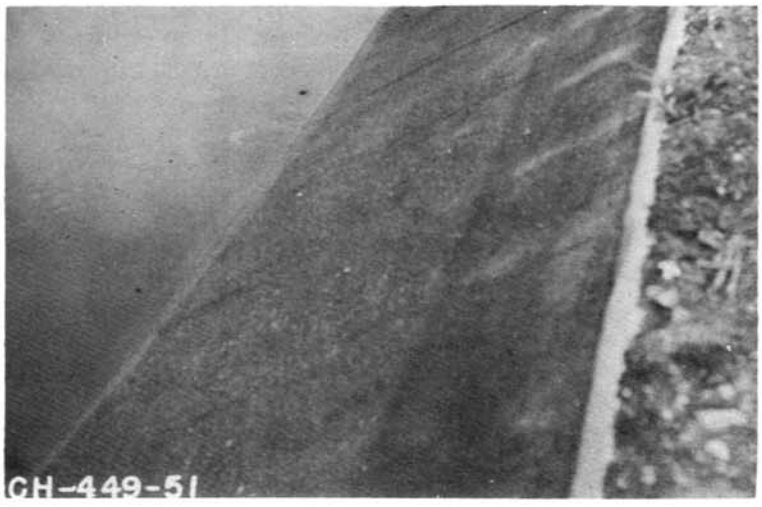
Due either, possibly, to too low an aggregate temperature or to too lean a mix, the in-place asphaltic-emulsion concrete lining was brown in color and lacked cohesiveness, the completed surface being easily abraded. Approximately a 30-foot length of this material was sealed with an application of 0.25 gallon of RC-O cutback asphalt per square yard of surface.



The asphaltic-emulsion concrete, as shown at left, after 8 years of service is still in place. It exhibits numerous cracks and is soft in spots.

The asphaltic-cement concrete, also plant mixed, consisted of a graded aggregate, 100 percent passing the #4 size screen and approximately 7 percent of 85-100 penetration asphalt cement. This material was placed at a temperature of about 350 degrees, and both side slopes and bottom were rolled as shown.

The resurfacing material was very good in appearance at the time placed and, as shown in the lower photograph, there are few cracks and very little spalling after 8 years of service and exposure. Some roller marks are still apparent and the protective resurfacing mat is intact and hard.



SUMMARY

By way of comparison at the time of placement, the pneumatic applied portland cement concrete resurfacing was the best in appearance, followed by the hot-mixed asphaltic-cement concrete, the pneumatically applied asphalt-emulsion, and the

filled hot-applied asphalt cement. From the standpoint of service, one would probably rate the "hot-mixed" asphaltic-cement concrete first, followed by the asphalt-emulsion concrete and the pneumatically applied portland cement mortar.

In general the entire resurfaced section of canal is considered in poor condition with the exception of the hot-mixed asphaltic-cement concrete. This latter shows some cracks and roller marks. Both these deficiencies probably could be eliminated partially by increasing the thickness of the resurfacing material and more careful rolling at the time of placement.

Many of the other resurfacing materials could have been more effective with continued maintenance, but the overall experienced gained is of considerable value, and that was the purpose of the experimental installations.

From the information gained from the experimental installations, a tentative specifications for the asphaltic concrete resurfacing of portland cement concrete has been prepared. These specifications are attached.

* * * * *

TENTATIVE
SPECIFICATIONS FOR ASPHALTIC CONCRETE RESURFACING

1. Asphaltic concrete canal resurfacing. General.--The asphaltic concrete resurfacing shall consist of a mixture of mineral aggregate, and asphalt, all mixed hot and laid in accordance with these specifications. The thickness of the asphaltic concrete resurfacing shall be as shown on the drawings. Prior to spreading and compacting the asphaltic concrete resurfacing, the contractor shall prepare the existing surfaces as hereinafter specified.

2. Preparing existing concrete canal surface.

(a) General.--Prior to applying prime and tack coats, the existing surfaces shall be prepared by cleaning.

(b) Cleaning existing canal surfaces--Just prior to applying the asphalt emulsion prime coat, the entire area to receive resurfacing shall be cleaned by power brooming. The brooming shall remove all dirt, sand, and broken pavement. Following the brooming, the area shall be cleaned with a suitable air-water jet removing all other deleterious materials which would prevent the prime coat from bonding to the pavement. The cost of all labor and materials used in cleaning shall be included in the unit price per square yard bid in the schedule for preparation of existing canal surfaces.

3. Prime coat. Immediately following the cleaning of the existing concrete canal surfaces, the contractor shall apply as asphalt emulsion prime coat. All puddles, pools, and free surface water shall be removed from the old lining just prior to the application of the prime coat. The prime coat shall consist of an SS-1 asphalt emulsion uniformly applied at a rate of 0.05 to 0.1 gallon per square yard by pressure spraying. The asphalt emulsion shall be applied over the entire area to be resurfaced.

4. Tack coat. A tack coat consisting of a 50-60 penetration asphalt cement shall be uniformly applied while hot at a rate of 0.15 to 0.25 gallon per square yard over the moisture free primed surface. The tack coat shall be applied by means of a pressure-type spraying distributor.

5. Asphaltic concrete.

(a) Mixing--The mixing plant used by the contractor shall be a pugmill type, designed and assembled so as to properly dry, heat, screen and mix the materials. The plant shall have screens capable, at normal speeds, of separating all aggregate to the required sizes. At least two storage bins, proportioned so as to insure adequate dry storage of the appropriate sizes of the aggregate, shall be provided. The break in gradation to determine limiting sizes of fine and coarse aggregate shall be determined in the field by the contracting officer. The plant shall be equipped for accurately proportioning the two sizes of aggregates and asphalt by weight, using either dial scales or multiple beam scales of a type approved by the contracting officer. Scales shall be accurate within one-half percent of all loads. The plant shall have a dryer, suitably designed to heat and dry the aggregate to specification requirements. Suitable accurate thermometric equipment shall be furnished for ascertaining the temperature of the aggregate

discharged from the dryer. Equipment for heating the asphalt shall consist of a retort or steam coils so designed that steam will not be introduced into the asphalt.

The mineral aggregate and the liquid asphalt shall be mixed in a pugmill type plant in accordance with the following: All lumps in the plant-mix material shall be broken up thoroughly before the mixture is placed on the lining. Mixing shall continue for a period of at least 30 seconds after all ingredients are in the mixer and until a uniform mixture of unchanging appearance is obtained, with all of the particles or aggregate thoroughly coated with liquid asphalt. The mineral aggregate shall be furnished in two sizes, and shall be stored in separate bins. The two sizes shall be combined in proper proportions as directed at the time of mixing. The aggregates shall be heated before entering the mixer, to a temperature not in excess of that consistent with proper mixing and laying, but in no case shall the temperature exceed 350° F. The placing temperature of the material shall be held as near 325° F as practical. All material shall be proportioned accurately by weight.

Additional filler, if required, shall be proportioned and blended with the mineral aggregate before screening into the separate bins. Filler may be added to the aggregate at the mixing plant by thoroughly premixing it with the other fine aggregate. Spreading filler over the top of aggregate pits or dumping it indiscriminately into the hopper at crushing plants will not be permitted.

The amount of liquid asphalt may vary between 8 and 10 percent, by weight, of the mineral aggregate, and the exact percentage will be fixed by the contracting officer. When a greater amount of liquid asphalt is required to produce a satisfactory mixture, due to the porosity of the rock, the quantity shall be increased above the limits herein specified. The liquid asphalt shall be added to the mixture at a temperature of not less than 250° F nor more than 325° F. The contractor shall furnish, and keep on the work at all times, an accurate thermometer suitable for determining the temperature of the liquid asphalt being added. The amount of liquid asphalt to be added shall be accurately weighed by means of an approved weighing device.

The contractor shall furnish a set of platform scales of sufficient size to weigh the trucks loaded with the prepared plant-mix material.

(b) Transporting--The mixture shall be transported from the mixing plant to the site of the work in trucks having tight, clean, and smooth beds which have been oiled with a minimum amount of approved thin oil to prevent adhesion of mixture to the beds. Each load shall be covered with canvas or other suitable material of ample size to protect the mixture from the weather. Deliveries of material shall be made so that spreading and rolling of all mixtures can be completed during daylight, unless artificial light satisfactory to the contracting officer is provided. Hauling over the newly completed lining will not be permitted.

(c) Spreading and compacting--The plant-mix resurfacing material shall be spread by means of a self-propelled type paver. The paver shall be equipped with an agitator, preferably of the pugmill type, and shall spread the material evenly and with uniform density and strike it off true to the required cross section. Screeds shall not follow minor irregularities on the existing canal surfaces, shall be readily adjustable and shall be provided with gages for accurate control of depth of spread. The required compacted thickness will be 1-1/2 inches. To obtain this required thickness, the contracting officer will determine the depth to which the screed is to be adjusted.

The asphaltic concrete resurfacing material shall be extended 12 inches up the canal side slope measured from the toe of the slope. The required compacted thickness shall be 1-1/2 inches. The upper edge of the asphaltic concrete resurfacing on the slopes shall be neatly trimmed and finished.

Material at joints shall be evenly spread by rakes immediately after the adjoining strip has been laid and before the roller has compacted the material.

The resurfacing material shall be compacted by rolling. Rolling shall begin as soon as possible after the material is spread: Provided, That no rolling will be permitted so long as the material "shoves" in front of the roller. A light 1-1/2- to 2-ton roller shall be used for the initial compaction followed by a 6- to 8-ton tandem roller.

All areas not accessible to the roller shall be compacted by hand tampers, approved by the contracting officer.

During rolling, all lumps or compressed masses of the mixture shall be removed and disposed of and the area filled with additional material and again rolled. The edges of the completed surfacing shall be trimmed uniformly to the required cross section before they are finally rolled and shaped. The completed surfacing, when ready for acceptance, shall be thoroughly compacted, smooth, true to grade and cross section, and free from ruts, humps, depressions, or irregularities.

The cost of all labor and materials used in furnishing, spreading and rolling plant-mix bituminous material shall be included in the unit price per ton bid therefor in the schedule.

6. Materials. Materials required for the repair and resurfacing shall be furnished in accordance with the following specifications. Number and symbols refer to Federal specification unless otherwise indicated.

(a) Emulsified asphalt--Emulsified asphalt for use as prime coat for the resurfacing shall conform to Federal Specification SS-R-674b, Type SS-1.

(b) Mineral aggregate--Mineral aggregate for use in plant-mix material shall be furnished by the contractor, shall be uniform in quality

and grading, and shall be free from adobe, vegetable matter, and other deleterious substances. The following designations in parentheses refer to method of test described in the fifth edition of the Bureau of Reclamation Concrete Manual:

(1) Grading--The mineral aggregate when tested by means of standard screens (Designation 4) shall conform to the following limits of gradation:

Sieve opening	Percentage by weight passing sieve
1/2 inch	100
No. 4	95-80
No. 10	80-60
No. 40	35-14
No. 200	6-14

No rock larger than 6 inches in any diameter shall be used in the rock crusher, in the event the contractor produces aggregates by crushing rock.

(c) Asphalt cement for tack coat and plant-mix--Asphalt cement for tack coat and plant-mix shall conform with the requirements of Federal Specification SS-A-706b, Designation AP-6, 50-60 penetration. Tests shall be in accordance with Federal Specification SS-R-406c.

REQUIREMENTS

TESTS	AP-6
Flash point, not less than	347° F
Softening point	104-140°
Penetration at 77° F, 100 grams, 5 seconds	50-60
Loss at 325° F, 5 hr., not more than	1 percent
(a) Penetration of residue at 77° F, 100 grams, 5 sec., as compared to penetration before heating, not less than	60 percent
Ductility at 77° F, not less than	40 cms
Bitumen (soluble in carbon disulphide) not less than	99.5 percent
(a) Organic matter insoluble, not more than	0.2 percent

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7. Measurement for payment. Measurement for payment for the various items of work to be performed in connection with the resurfacing will be in accordance with the following:

(a) Preparation of existing canal surfaces--The unit of measurement for payment will be the square yard and measurement will be made in the field of the actual surface area prepared.

(b) Furnishing and applying asphalt emulsion for prime coat--The unit of measurement for payment shall be the ton (2,000 pounds). Measurement will be made of the actual volume of undiluted asphalt emulsion applied and converted to tons of material in accordance with the following table:

Type of asphalt	Gallons per ton at 77° F
SS-1 type asphalt emulsion	240

(c) Furnishing and applying asphalt cement, AP-6, for tack coat--The unit for measurement for payment shall be the ton (2,000 pounds). The measurement of asphalt cement will be made of the actual weight of asphalt cement used in the tack coat. If the measurement of asphalt by volume is used, a gallon shall be construed to be a gallon at 60° F. The following table shall be used for converting volume to weight:

Type of asphalt	Gallons per ton at 60° F
AP-6, 50-60 penetration	235

(d) Furnishing and applying asphalt cement, AP-6, for asphaltic concrete--The unit of measurement for asphalt used in the asphaltic-concrete canal lining shall be the ton (2,000 pounds). The tonnage to be paid for shall be the number of tons of asphalt used in the accepted work, as determined by shipping weights. No payment will be made for asphalt that is wasted.

(e) Furnishing and applying plant-mix asphaltic concrete resurfacing--The unit of measurement for payment for plant-mix asphaltic concrete resurfacing shall be the ton (2,000 pounds). Payment quantities of asphaltic concrete shall be the ton on the basis of the net weight of asphaltic concrete placed in accordance with the area and thickness of lining shown on the drawings or established by the contracting officer.

*TYPICAL ESTIMATE OF QUANTITIES AND PAY ITEMS

Item	Work or material	Quantity
1	Preparation of existing canal surfaces	3,611 square yards
2	Furnishing and applying asphalt emulsion for prime coat	1.5 tons
3	Furnishing and applying asphalt cement for tack coat	4 tons
4	Furnishing asphalt cement for plant-mix asphaltic concrete	26 tons
5	Furnishing and applying plant-mix asphaltic concrete	285 tons

*Assumed: (a) 2,500 linear feet of canal
(b) 11-foot bottom width
(c) Resurfacing to extend 1 foot up both side slopes
(d) Asphaltic concrete at 140 lb/cu ft
(e) Asphalt content of mix = 10 percent.

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