A REVIEW OF DEVELOPMENT OF THE BENTONITE SEDIMENTING METHOD OF SEALING IRRIGATION CANALS

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INTRODUCTION

During the past five and one-half years, research and development work on the bentonite sedimenting methods of sealing irrigation canals has been coordinated and accomplished through a research project at Colorado State University. Considerable laboratory work has been completed, but most of the activity has been concentrated, especially in the last two years, on development trials in operating canals and ditches. These trials have been financed and carried out by various irrigation districts and companies. Other cooperators in the project have included at various times, the Agricultural Research Service, the Bureau of Reclamation, the U. S. Geological Survey, and a number of bentonite and chemical companies.

The purpose of this paper is to summarize the development to date of the bentonite sedimenting methods as applied to different canal bed materials. References for detailed information are also listed.

It has been found that different techniques are necessary to bring about effective sealing to different types of canal bed conditions. Research efforts have been directed toward finding the proper techniques for three major types: (1) silty and sandy sub-grade materials, (2) rocky and gravelly sub-grade materials, and (3) heavy deposits and movement of bed-load sand.

SEALING METHOD FOR SANDY BED MATERIAL

In the early research work, a high-swell bentonite was dispersed into canal water with a jet mixer. The sealing action was brought about by ponding the clay-water mixture in the section being treated. Where the water was hard a water softener or dispersant was added to prevent or reduce the flocculation and settling out of the bentonite. In almost all instances, the treatment produced an excellent initial seal, but in many of these trials the life of this seal was limited. A canal dry-out immediately after treatment was found especially damaging to the surface seal.

A solution to overcome the surface seal problem was developed in the Riverton area of Wyoming by a local farmer, Charles Ridgeway, assisted by M. A. McNamee, Wyoming Agricultural Extension Service. They worked the bentonite into the bed material by harrowing the sides and the bottom of the canal after the section was filled with the bentonite sealing mixture. This procedure enabled the bentonite to seal in depth while retaining the advantage of concentrating the sealing action in the high-loss areas. Thus the "bentonite dispersion method" was established as definitely practicable.

The inclusion of this method in the Wyoming ACP Handbook for 1958 promoted wide-spread interest among the water users. The county agents and SCS technicians began to receive requests for information on the application procedure. In response to these requests, the Wyoming Agricultural Extension Service, assisted by the Wyoming Natural Resource Board, conducted an educational demonstration program in 1957 and 1958. This program completed twelve sealing installations in the following areas of Wyoming: Lander, Greybull, Cody, and Pinedale.

The Extension Service, through M. A. McNamee, furnished the demonstration equipment, and the Resource Board, through R. D. Dirmeyer in a consulting capacity, furnished the technical assistance including the follow-up evaluation of procedures and results.

In general, the results of these installations were very satisfactory, and improvements in technique were introduced as experience increased. Excellent results were obtained in the jobs done by contractors in the Riverton area although the costs were higher because of the more proficient procedures used. Some essential data of these installations are listed in the following table.

	Cost per Sq. Yd. (Cents)	Bentonite Per Sq.ft. (lbs)	Canal Capacity (cfs)	Length Treated (ft)	Seepage Reduction
Minimum	6	0.2	10	600	50 percent
Maximum	36	2.5	200	28,596	complete

For a detailed report and discussion on the "bentonite dispersion method", see "An Evaluation Report on Recent Bentonite Sealing Work in Wyoming Canals" by R. D. Dirmeyer, dated March 1959, available from the Wyoming Natural Resource Board, Cheyenne, Wyoming.

SEALING METHOD FOR ROCKY MATERIALS

Where the ditch bed is gravelly and rocky, the holes and leaks are so big that bentonite mixture can easily pass through them. Therefore, the problem is not one of surface seal but one of retention. The sealing agent must be retained by the bed material so that the leaks will remain plugged.

A solution to this problem was developed during 1956, 1957 and 1958, by the Twin Lakes Reservoir and Canal Company, assisted by Colorado State University research personnel. Efforts were made to seal the connection canal at the west portal of a transmountain tunnel near Aspen, Colorado. The bed material consisted of intensely fractured granite and loose talus. Initial trials of bentonite sedimenting failed because the sealing mixture could not be prevented from completely passing through the leaks. Finally a successful method was evolved: "the multiple-dam method".

In this method a series of dams was built in the ditch section from a mixture of granular Wyoming bentonite, pit-run Colorado bentonite, and wet sawdust. These dams rose to the highwater mark and were spaced about 100 yards apart, depending on the canal slope. Water was then turned in, beginning with the first dam upstream. As the water overtopped the dam, a power shovel was used to break the dam up to make a lumpy slurry. This procedure was repeated at each successive dam.

Good sealing results were produced in the connection canal, which is about 7800 feet long and has a capacity of 350 cfs. Before 1956 it was necessary to turn in 10 cfs at the upper end of the canal to get a trickle at the lower end. By the summer of 1958 (the third season since the installation in 1956) 6 cfs was turned in at the upper end and 5.2 cfs was obtained at the lower end. The cost of the installation was $8,000, or about 35 cents per sq. yd. of wetted area. Compare this with the next

cheapest lining, a buried bentonite membrane, which was estimated recently for this canal at $90,000.

A somewhat similar method of canal sealing has also been developed by C. C. Feltner of the Fremont Irrigation Company of Pinedale, Wyoming. His method involves the use of a coarse bentonite, which is washed by a water jet into flowing canalwater, just upstream from the suspected leaky zones in the canal bank.

PROBLEMS CAUSED BY BED LOAD SAND DEPOSITS

As a climax to several years of field and laboratory investigations, the Imperial Irrigation District completed in October 1957, a large scale sediment sealing trial in Reach No. 2 of the Coachella Canal near Holtville, California. While a number of clay materials were investigated, a chemical mixture, SS-13, developed by the Brown Mud Company of Los Angeles, California, was used in the trial.

In evaluations since the installations, it seems that the sealing effects were less than anticipated. It has been theorized that the heavy bed-load sand conditions in Reach No. 2 of the Coachella Canal, were at least partially responsible for the apparent poor results from the SS-13 treatment. Laboratory data indicates that the sealing action of SS-13 is mainly a surface seal. Based on observations made since the installation, we know that the bed-load sand is actively moving, and therefore, for a lasting effect, the seal must be under and not on the surface of the moving and shifting bed-load deposits. These deposits in Reach No. 2 vary from a few inches up to as much as 2 feet in thickness.

Additional research is planned in exploring several promising possibilities for a suitable sealing method where bed-load sand is a serious problem, but as yet a satisfactory method has not been developed.

RECOMMENDED METHODS

The following specification has been accepted by the Wyoming State ASC Technical Committee and recommended for inclusion in the 1959 ACP Handbook:

The ditch section must first be cleaned, shaped, and rip-rapped (or otherwise controlled against erosion) to the satisfaction of the responsible technician. One of the two sealing methods; or, in special cases, any successfully demonstrated compromise between them, shall be used as acceptable to the technician.

1. The Dispersion Method shall be used in sandy channels having sufficiently flat grade for ponding and having bottom and sides responsive to harrowing so that the bentonite can be made to penetrate the soil rather than to form a temporary surface seal. The ditch section shall be effectively dammed by either water-proofing an existing check structure or constructing a temporary earth dam. The bentonite used shall have a grit content of six per cent or less, and a colloidal yield of eighty per cent or more. A mixing method acceptable to the technician shall be used to produce, at a desired mixing rate, a bentonite-water mixture of average 1.0 per cent colloidal bentonite by weight. Approximately 3/4 lb. of dry bentonite per cubic foot of water is needed for this concentration. Colloidal mixture shall be ponded above the high water line at the upper end of the pond and be kept ponded for at least 48 hours. After the maximum ponding depth is attained, the ditch sides and then the bottom shall be stirred by a harrow, disc or similar implement. This shall be done at least twice each day for two days and in a manner producing a minimum of bank sloughing.

Known extreme high loss areas shall be blanketed with a tamped soil-bentonite mixture prior to ponding. Additional bentonite shall be added whenever an unexpected insufficiency occurs because of bentonite flocculation, or excessive loss of mixture during filling.

2. The Multiple Dam Method shall be used in gravelly or rocky channels having steep grade and ditch bottom and sides unsuitable for harrow operation. The ditch section shall be divided by an adequate number and spacing of dams built of a mixture of granular high-swell bentonite (same requirements as above) and some supplemental bridging agent such as a local low-grade bentonite or wet sawdust. Composition of this mixture material shall be acceptable to the responsible technician. Water shall be released from the upstream end. As the first dam is overtopped, power equipment, such as a dragline or back-hoe, shall be used to help break up the dam and obtain a lumpy mixture at maximum speed. The same process shall be repeated for the remaining dams.

In case of extremely rocky and open materials, additional quantities of the sedimenting mixture shall be spread or water jet sluiced on the ditch bank areas and wherever deemed necessary by the technician.

ADDITIONAL INFORMATION

For additional information that outlines specific how-to-do instructions, reference is made to the following booklets by R.T. Shen:

1. Sealing Sandy Ditches with the Bentonite Dispersion Method.
2. Sealing Rocky Ditches with the Bentonite Multiple-Dam Method.
3. Mixing Bentonite for Sealing Purposes.
4. Testing Bentonite for Sealing Purposes.
5. Sealing Farm Ponds with Bentonite.

These booklets are being published jointly by the Colorado and Wyoming Extension Services, and will be ready for distribution within a few months.