SEDIMENTING CANALS

By

R. D. Dirmeyer Jr., Research Engineer

For presentation at the Ninth Annual Meeting
of the Four States Irrigation Council
Denver, Colorado

January 14-15, 1960

Colorado State University
Civil Engineering Department
Fort Collins, Colorado

CER60RDD2

SEDIMENTING CANALS

by

R. D. Dirmeyer Jr., Research Engineer

For presentation at the Ninth Annual Meeting
of the Four States Irrigation Council
Denver, Colorado

January 14-15, 1960

Colorado State University
Civil Engineering Department
Fort Collins, Colorado

CER60RDD2

Introduction

It is my great pleasure to appear again before this group to discuss recent developments in the use of water-borne clay sediments, such as bentonite, in the low-cost sealing of irrigation canals. My report today will be concentrated mainly on the research results that have become available since my last report to this group in 1958.

As many of you will recall, the Sediment Sealing Project was organized at Colorado State University in July, 1953. From the project beginning some six and one-half years ago the purpose of the project has remained constant. This purpose is to develop low-cost canal sealing methods for controlling the many canal seepage problems where the better linings of concrete, asphalt and compacted earth are too expensive to consider. I have purposely referred to the conventional linings as "better" because I would like to emphasize that the sediment sealing methods definitely do not take the place of the conventional canal linings that usually accomplish more than seepage control alone.

It was not so in the early work, but in recent work, a very definite emphasis has been placed on the "do it yourself" idea. Thus, while laboratory studies have been carried out at the University and in the laboratories of cooperators, such as the Bureau of Reclamation, these studies have been mainly of a supporting basic research or service nature. The major emphasis of the program has been concentrated on field studies of trials, installed and financed by cooperating irrigation organizations. With the "do it yourself" values clearly in mind, we have, in every way possible in recent work, restricted our efforts to advisory and evaluation activities that reinforce rather than interfere with the normal supervisory activities of the cooperator, district or company.

We feel that this is truly a "partnership" approach to research. A clear understanding of the local canal conditions is very essential to the success of the development and research work. With the approach outlined above, a maximum opportunity for obtaining this understanding is provided.

The University assistance and follow-up studies at the field installations have been financed, in part, directly by the irrigation district cooperators and, in part, by contract with Federal agencies, such as the Agricultural Research Service and the Bureau of Reclamation. I have purposely mentioned how our research and development activities have been financed for two reasons.

First, I wish to express on behalf of myself and the Colorado Agricultural Experiment Station, my deep appreciation for the past support furnished to our research and development project by irrigation groups, many of whom are represented by those in attendance here today.

Secondly, I would like to point out that this type of joint venture or cooperative project financing seems to provide one very practical answer toward the financing of additional research that is greatly needed in the broad field of optimum utilization of our water resource.

In regard to the latter point, and in recognition of a growing tendency of legislators to favor the financing of projects "to the greatest possible extent by those who will benefit most directly," many Universities and Colleges have organized non-profit and separate corporations. Typical of these is the Colorado State University Research Foundation. This corporate instrument provides legal means whereby the institutions can enter into contractual arrangements to provide specified research services to private and public organizations.

My report today will be accomplished mainly with color slides of the actual research and development work at the field sites in operating canals. First, let us consider in brief detail the sedimenting material that has been used in all but one of the field trial installations.

What is Bentonite?

In short, bentonite is a natural clay substance, usually the mineral montmorillonite. It is most commonly formed by the chemical alteration or decomposition of glassy igneous material, usually volcanic ash.

An understanding of its origin is, I believe, most important because it explains why the bentonites are so extremely variable, both in clay content and in physical properties. This variability is related to the differing rates and nature of the weathering or chemical break-down of the various minerals found in the original rock material.

Its orgin explains why we find such a wide range of so-called bentonites ranging from bentonitic shales with as little as 20 percent clay or montmorillonite up to the true bentonites that are commonly defined and restricted to those materials containing 85 percent or more montmorillonite.

Another important characteristic of bentonite is its small particle size. A pure bentonite has a soapy feel when wetted and displays little or no "grittiness" when tasted and chewed.

Even the pure bentonites vary. Some are the so-called high-swell bentonites, sometimes referred to as sodium bentonites. Others are referred to as low-swell or calcium bentonites. Most of the commercially available bentonites in this area are of the high-swell or sodium variety. These are mainly mined in Wyoming, South Dakota and Montana and are used mostly in the drilling of oil wells and in foundry sands. Almost all of the bentonites used in our past sediment sealing research have been of the commercial high-swell bentonite type.

In contrast to the somewhat restricted occurrence of the high-swell bentonites, the low-swell varieties are found in many areas, but as yet are not commercially developed to any significant extent. Because of the important cost saving potentialities, our recent project activities have been concentrated on exploring the possibilities of utilizing these locally occurring varieties of low-swell bentonite. This important development will be discussed in more detail later in this talk.

Slides 1 through 5 illustrate how the bentonites, both high-swell and low-swell, appear in their natural state and how they are mined.

Sealing Methods for Small Canals in Sandy Soils

(with stable grade and capacity less than 100 cfs.)

As you may recall from my last report to this group, one of the major sediment sealing trials was installed by the Bureau of Reclamation in Lateral 1 of the Pathfinder Irrigation District of the North Platte Project. Initially an excellent seal was obtained on this trial; however, after a canal dry-out shortly after the installation was made, the seal was almost completely lost.

As result of follow-up investigations, both in the field and in the laboratory, it was determined that the short life was related to the inability of the bentonite to penetrate into the sandy materials in the lateral.

Subsequent development work in Wyoming has overcome this penetration problem. The latter development work was carried out by irrigation farmers and groups assisted by the Wyoming Natural Resource Board and the Wyoming Agricultural Extension Service. I assisted in this work in an advisory capacity.

Details of this development work are contained in an "Evaluation Report on Recent Bentonite Sealing Work in Wyoming Canals," published by the Wyoming Natural Resource Board. Following the completion of this report, five circulars on the use of bentonite for sealing irrigation ditches and reservoirs were prepared for distribution by the Extension Services of Colorado and Wyoming.

The circulars that apply to the sandy ditches are listed below:

Colorado No.	Wyoming No.	Title
202A	158	Sealing Sandy Ditches with the Bentonite Dispersion Method, by R. T. Shen
204A	160	Mixing Bentonite for Sealing Purposes, by R. T. Shen

The dispersion method of sealing ditches was first included as a practice eligible for USDA cost sharing in the 1958 ACP Handbook for Wyoming.

Color slides 6 through 12 illustrate the development and main features of the Wyoming bentonite dispersion method of sealing sandy ditches.

Sealing Methods for Small Canals in Rocky Materials

(with stable grade and capacity less than 400 cfs.)

For reasons that seem obvious, the bentonite dispersion method that works fine in sandy soils, commonly will not produce satisfactory results in coarse rocky or gravelly materials. In contrast to the lack of penetration problem in sandy soils, the dispersed bentonite alone will commonly shoot through the large cracks and openings of the rocky soils, without sealing, and in extreme cases, may even appear in spring or seepage waters below the canal section being treated.

Research efforts have been devoted to two general methods of controlling canal seepage in the rocky materials.

The first method involves the use of a mixture of sedimenting materials, including a granular grade of high-swell bentonite, designed to both plug or bridge the large openings and at the same time produce a satisfactory sealing action. Color slides 13 through 21 illustrate the development steps for this mixed sediment method. It is commonly called the Multiple-Dam method. The Extension Service circular that describes this method of canal sealing is listed below:

Colorado No.	Wyoming No.	Title
203A	159	Sealing Rocky Ditches with the Bentonite Multiple-Dam Method, by R. T. Shen

The second method--still in the research and development stage--involves the use of local bentonite materials in a multiple-dam type of instllation. Color slides 22 through 27 illustrate some of the preliminary work of this general type that has been conducted in several Colorado canals and that has utilized a local source of Colorado low-swell bentonite.

Completed Research Work

Thus, in summary, the research and development efforts may be considered complete for two sediment sealing methods where a Wyoming high-swell bentonite is used as the sedimenting agent. Obviously, additional adaptation work may be required for some applications but satisfactory general procedures have been developed for the following sedimenting methods:

1. Bentonite dispersion method for use in sandy ditches that are not actively eroding or cutting their banks or bed and that have a maximum capacity of 100 cfs or less. See slides 28 and 29. The amount of high-swell bentonite needed is estimated by the following formula:

$$\text{Tons of bentonite} = \frac{\text{Av. end area (ft)} \times \text{length (ft)} \times 62.4\ \text{(lbs)} \times 1\ (\%)}{2000 \times 100}$$

but not less than:

$$\text{Tons of bentonite} - \frac{\text{Av. wetted perimeter (ft)} \times \text{length (ft)} \times 1\ \text{(lbs)}}{2000}$$

2. Multiple-dam method for use in rocky ditches that are stable and whose capacity does not exceed 400 cfs. See slides 30 and 31. The amount of bentonite is calculated by the second formula above. The application rate of 1 lb of Wyoming bentonite/sq ft of wetted area remains as a minimum figure irregardless of the amount of additional bridging materials that may be required to obtain a satisfactory seal.

In recent evaluations of installations made in Wyoming and Colorado with the two methods just mentioned, the cost of the bentonite treatment ranged from less than one cent to thirty-six cents per square yard of wetted area in the treated section of canal. However, it has been noted that the shipping costs of the Wyoming high-swell bentonite becomes an important deterring factor in work outside of Wyoming--and incidently also for work in western Wyoming. Also, on some of the past sedimenting installations, the need for a limited amount of follow-up maintenance work is becoming apparent.

New Research Work on Low-Swell Bentonites

In an effort to combat the shipping cost problem and also with hopes of simplifying the installation and follow-up maintenance procedures, preliminary investigations into the possibilities of finding and utilizing local sources of bentonite for canal and reservoir sealing purposes have been started in Colorado. The initial results of this work are most promising.

It now seems apparent that suitable bentonites could be developed in many areas of Colorado and limited application experience with Colorado low-swell bentonites, such as the Lamberg bentonite from near Salida, Colorado, indicates several important advantages over the high-swell variety of bentonite. These apparent advantages are listed below:

1. Cost--The cost of the local bentonite has ranged from $7.00 to $20.00/ton delivered and installed at the canal site. Comparable cost figures for the Wyoming high-swell bentonite in Colorado canals start at $40.00.

2. Ease of mixing--The local material can be used in the multiple-dam method in a pit-run form. The Wyoming high-swell material used in most of the past sedimenting work has been a milled product that is Kiln-dried, ground and sacked. For best results this powdered material requires special mixing equipment, such as a jet mixer, requiring, as a minimum, a high-pressure pump and an air compressor.

3. Reaction with hard water--A high-swell sodium bentonite when mixed into hard water will commonly be converted into a low-swell calcium bentonite. Water softening agents can be used to prevent this reaction during the sedimenting procedure but a very detrimental shrinking and cracking action probably will take place when the normally hard water is run in behind the soft sedimenting water. This chemical exchange and volume decrease problem is adequately provided for in the harrowing step in the bentonite dispersion method. Using a locally available and much cheaper low-swell calcium bentonites to begin with seems like a much more direct and practical solution to the problem since the possibilities of a harmful reaction between the clay and the water are avoided.

It is also true, however, that the low-swell bentonites have disadvantages. These are briefly outlined below:

1. Variability--The Wyoming high-swell material is commercially available and, consequently is relatively uniform in quality. The locally available low-swell bentonites, in most cases, are not commercially developed at this time. Thus, the very important evaluation and development work for each bentonite property remains to be accomplished. Minimum standards of quality have not as yet been established.

2. Installation methods--The low-swell, easy-mixing bentonites seem to work very well in the multiple-dam method of application for rocky canals; however, suitable methods of utilizing the low-swell material in sandy canals, especially the very large canals, have not as yet been developed.

Closing Remarks--It is felt that the development problems facing the use of low-swell bentonites in sealing canals can be solved. My staff and I have the desire, facilities and capabilities to go ahead with the work--but unless sufficient research funds for the work can be found within the next few months, this Colorado State University project will be terminated. In other words, at this time especially, we will welcome additional cooperators.

As one last item in my last report to this group mention was made of research and development activities at two additional major trial sites, not as yet covered in my report to you today. The two sites are (1) the Lateral 19.3 site in the loessial soils of the Central Nebraska Public Power and Irrigation District, and (2) the Coachella Canal site in the Imperial Irrigation District area of Southern California.

In both instances, the sealing effect, with bentonite in Lateral 19.3 and with SS-13 in the Coachella Canal, was less than hoped for. Factors contributing to the apparent fast break-down of sealing are listed by sites below:

1. Lateral 19.3--The major problem at this site is that the canal section is not stable. A combination of wave erosion and many crayfish burrows apparently seriously cut-down on the bentonite sealing--especially in the upper bank areas near the high-water line. An unexpected flocculation problem during the installation also cut down on the sealing effect in the upper bank areas. See color slides 32 through 34.

2. Coachella Canal--This canal section also is not stable. Bed-load sand is moving along the bottom of the canal. The initial sealing with the SS-13 was accomplished on the top of the bed-load sand layer on the bottom of the canal. After the SS-13 treatment and as normal water delivery was resumed, the sand started moving again. This apparently destroyed or at least badly damaged the seal. See color slides 35 through 41.

In both cases, the answer to the limited life of the seal boils down to one of two alternatives. The first alternative is to stabilize the banks in the loessial soil of the Nebraska trial or the bed-load sand of the California trial. Stabilization, in the case of loessial soil may be possible, but for the bed-load sand it probably would be a difficult and perhaps impractical task. A more direct solution could involve the periodic addition of locally available, pit-run clay materials at a time of maximum flow in the canals. Here again, however, additional development work will be required by an experienced staff.