Progress Report

of

SEDIMENT SEALING INVESTIGATIONS

by

R. D. Dirmeyer, Jr.

Prepared for

Regional Drainage Research REview Conference

Reno, Nevada

February 2-3, 1960

Colorado State University
Engineering Research
Fort Collins, Colorado

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Introduction

This report is on recent developments in the use of water borne clay sediments, such as bentonite, in the low-cost sealing of irrigation canals. Since many of you are acquainted with the work being carried on by the Sediment Sealing Project at Colorado State University, the introductory remarks will be cut to a minimum.

Several of the most important background items are:

1. The purpose of the project is to develop low-cost canal sealing methods for controlling the many canal seepage problems where the conventional linings of concrete, asphalt, or compacted earth are too expensive to consider.

2. The major emphasis of the program has been concentrated on field studies of trial installations; installed and financed by cooperating irrigation companies and districts. Thus, while laboratory studies have been carried out at the University and in the laboratories of cooperators, such as the Bureau of Reclamation, and the Bureau of Mines, the laboratory studies have been mainly of a supporting or service nature for the field studies.

3. The "do it yourself" idea has been stressed in the field studies. Our research project efforts have been concentrated on advisory and follow-up evaluation that reinforce rather than interfere with the normal supervisory activities of the cooperating district or company. As an additional reinforcement to the "do it yourself" idea, the recent development trials in Colorado and Wyoming have been set-up on a combination development and demonstration basis. The preliminary meetings, some of which have been public meetings, and the trial work has been coordinated through the local SCS technicians and County Agents. ACP cost sharing asistance has been made available on many of the recent trials.

4. This cooperative project or "partnership" approach to an applied research problem has many important advantages, and obviously it also has some disadvantages. Without going into detail, I believe that you can appreciate both facets of such a research and development relationship.

5. As one final item of background information, for every dollar spent in support of the direct costs of the research project, the cooperators have spent approximately two dollars on the associated field trials. In other words, in the past four years, contract support of the project by the Agricultural Research Service and the Bureau of Reclamation totaled about $64,000. Matching expenditures by cooperating irrigation districts totaled more than $125,000 for the same period.

Under the contract program between the Agricultural Research Service and Colorado State University for the period of January 1957 to January 1960, research and development work was conducted at five sites in irrigation canals. The development work with a Wyoming high-swell bentonite at two of the sites--the Lateral 1 Site (Wyoming) in sandy materials and the Twin Lakes Site (Colo.) in rocky materials--is essentially complete. Work at the three remaining sites--the Lateral 19.3 Site (Nebraska) in loessial soils, the Coachella Canal Site (California) in sandy soils, and the Coors Farm Site (Colorado) in gravelly soils--is not complete

The status of work at each of the sites mentioned above is briefly discussed in this report; but first, let us consider a few of the important characteristics of bentonite. This material was used as the sedimenting agent in all of the trials except one.

What is Bentonite?

Briefly, bentonite is a natural clay substance, composed mainly of the clay mineral montmorillonite. It is commonly formed by the chemical alteration of a glassy igneous material, usually volcanic ash.

An understanding of its origin is 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 origin explains why such a wide range of so-called bentonite is found; ranging from bentonitic shales with as little as 20 per cent clay or montmorillonite up to the true bentonites that are commonly defined and restricted to those materials containing 85 per cent 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 a small particle of the bentonite is tasted.

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. The most common comercially available bentonites 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 as a bonding material in foundry sands. Almost all of the bentonites used in our past sediment sealing research have been of the commerical 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 as not commercially developed to any significant extent. Because of the important cost saving potentialities, 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 paper.

Completed Research Work

In general, 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. This does not imply, of course, that further basic research on the mechanisms of the sealing process are not needed. It is also obvious that additional adaptation work may be required for some canal applications but satisfactory general procedures have been developed for the following sedimenting methods:

1. The bentonite dispersion method -- This method can be used 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.

2. The bentonite multiple-dam method. -- This method can be used in rocky ditches that are stable and that have a maximum capacity of 400 cfs or less.

The early development work on the bentonite dispersion method was accomplished in an installation made 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 a 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. However, subsequent development work in Wyoming resulted in a harrowing of the canal banks and bottom to 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.

General details relating to this type of canal sealing installation which has been eligible for USDA cost sharing in Wyoming since January 1958, are outlined in the following publications:

1. Evaluation Report on Recent Bentonite Sealing Work in Wyoming Canals, by R. D. Dirmeyer, Jr., Wyoming Natural Resource Board, March 1959.

2. Sealing Sandy Ditches With the Bentonite Dispersion Method, by R. T. Shen, Extension Service Circular -- Colorado No. 202A and Wyoming No. 158.

3. Mixing Bentonite for Sealing Purposes, by R. T. Shen, Extension Service Circular -- Colorado No. 204A and Wyoming No. 160.

The development work on the multiple-dam method for use in sealing rocky materials was accomplished by the Twin Lakes Reservoir and Canal Company in their Trans-Mountain System near Aspen, Colorado. In early work at this site and in contrast to the lack of bentonite penetration problem of the sandy soils, the main problem was one of too much bentonite penetration. Dispersed bentonite alone would not seal the rocky materials. The method finally evolved uses a granular type of high-swell bentonite in combination with hole-plugging or bridging agents, such as local bentonite and wet sawdust.

General details on this method involving the use of a Wyoming high-swell bentonite are outlined in the Extension Service Circular, Sealing Rocky Ditches with the Bentonite Multiple-Dam Method, by R. T. Shen, Colorado No. 203A and Wyoming No. 159.

Research Work Not Complete

The research and development work, as grouped into this "unfinished business" category is briefly outlined by site in this discussion.

Lateral 19.3 Site in loessial soil -- An installation with a high-swell bentonite was made at this site in the spring of 1959. A preliminary study of the water loss data before and after this treatment indicates only a partial sealing effect carrying through to the end of the first season following the installation. Factors that may have contributed to this loss of seal are (1) wave erosion and beaching action at water line in canal, (2) extreme number of crayfish burrows or holes in treated reaches. Also, an unexpected flocculation of the bentonite occurred during this installation. All of these factors combined undoubtedly had an adverse effect on the seal obtained in the bank areas, particularly in the upper bank area just below the high water line.

Coachella Canal Site in sandy materials -- An installation with an oil-base material, designated SS-13, was made at this site in the fall of 1957. As with the Lateral 19.3 trial, the loss data indicates only a partial sealing effect enduring after one year. In this instance apparently a good seal was obtained initially, but as normal water deliveries were resumed the bed-load sand on the bottom of the canal started to move again. This seems to have destroyed or at least badly damaged the SS-13 seal.

Coors Farm Site in gravelly materials -- No installation has been made, as yet, at this site. A high water table has eliminated the need for sealing during the past few years; thus, this site has been eliminated from the sites to be described in a final report that is now being prepared for the Agricultural Research Service.

New Research on Low-Swell Bentonite

In recent evaluations of installations made in Wyoming with a high-swell bentonite, the cost ranged from less than one cent to thirty-six cents per square yard of wetted area in the treated section of canal. This cost and the favorable sealing results of the recent work is producing a steady gain in the amount of sedimenting work in central Wyoming. The "climate" with respect to interest in making installations, in western Wyoming and in other areas outside of Wyoming is not as favorable. The shipping cost and the mixing cost of the Wyoming high-swell bentonite are deterring factors. Also, the need for a simple follow-up maintenance procedure is becoming apparent. This last consideration is especially important where the canal bed or banks are unstable as in the canals in loessial soils (Lateral 19.3) and in canals with an active bed-load sand problem (Coachella Canal).

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

It now seems that suitable bentonites could be developed in many areas of Colorado. Limited installation experience in Colorado with local low-swell bentonites such as the Lamberg bentonite from near Salida, Colorado, indicates important advantages over the high-swell variety of bentonite. These advantages are:

1. Cost--The cost of the local bentonite 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 a low-cost, pit-run form in a multiple-dam method of application. 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. Polyphosphate 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. However, using a locally available and much cheaper low-swell calcium bentonite 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 briefly are:

1. Variability -- The Wyoming high-swell material is commercially available and is relatively uniform in quality. The locally available low-swell bentonites, in most cases, are not commerically 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. Suitable methods of utilizing the low-swell material in sandy canals, especially the very large canals, have not, however, as yet been developed.

Summary

It has been concluded that the research and development work on the "dispersion method" of sealing irrigation canals with a Wyoming high-swell bentonite is complete. Actually, this conclusion is not entirely true because, for example, a follow-up evaluation of results, reported in the "Evaluation Report" published by the Wyoming Natural Resource Board, has not been completed. Similar situations, to varying degrees, also exist for the other trials that have been installed. Every effort is being made to obtain research funds for this type of follow-up research and development work. This problem of funds is not, as all of you well know, an easy problem to solve. From our experience at least, research money for follow-up studies at field trial installations is difficult to locate.

In regard to the use of low-swell, locally-available bentonites for canal sealing, important research and development problems remain to be solved. Practical answers are needed for questions, such as: How much bentonite is needed for sealing of various soil types? How is the material installed in sandy soils? In loessial soils? In canals with a bed-load sand problem? What are the minimum specifications for a low-swell bentonite? Will this specification vary with the types of pervious soils found in canals? Are repeat treatments needed? If so, how often? Is a 100% seal needed or will a partial seal be satisfactory? Can the side-effects noticed with naturally muddy water, such as stabilization of banks and suppression of under water weeds, be obtained with bentonite sedimenting?

We are confident that the practical answers needed for the research and development questions, such as listed above, can be obtained by a cooperative project approach, invloving not only irrigation districts and companies but also other research organizations. If the research funds can be found, the answers can be obtained.