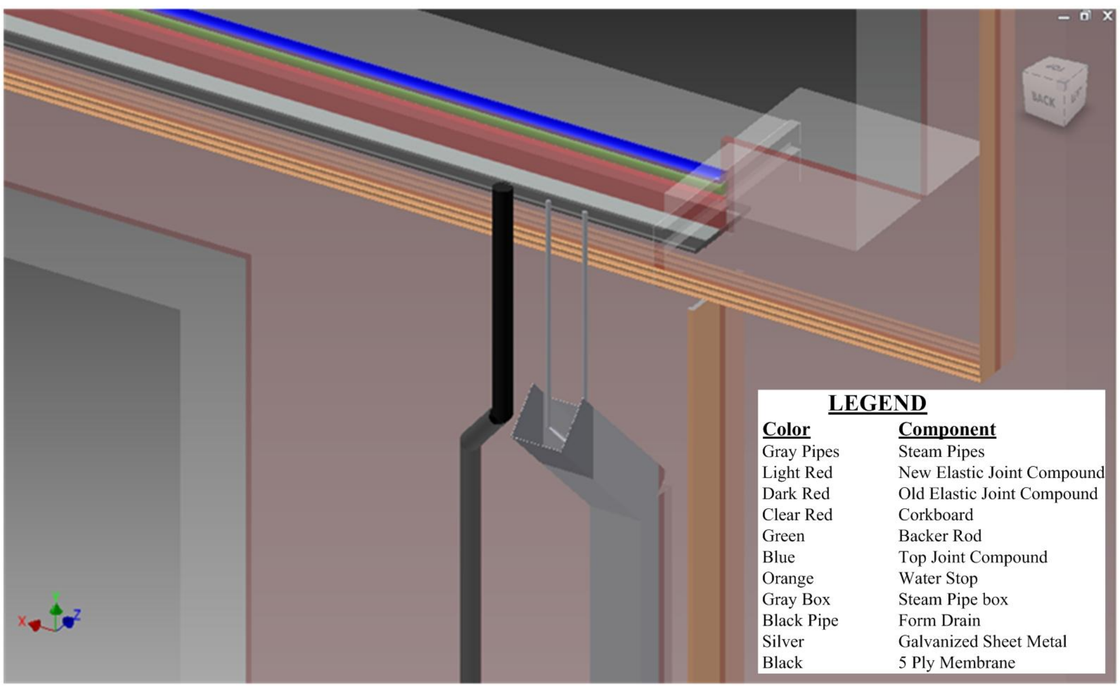
RECLAMATION

Managing Water in the West

Water Operation and Maintenance Bulletin

No. 228



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This *Water Operation and Maintenance Bulletin* is published quarterly for the benefit of water supply system operators. Its principal purpose is to serve as a medium to exchange information for use by Bureau of Reclamation personnel and water user groups in operating and maintaining project facilities.

Although every attempt is made to ensure high quality and accurate information, the Bureau of Reclamation cannot warrant nor be responsible for the use or misuse of information that is furnished in this bulletin.

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Cover photograph: 3-D diagram of a typical expansion joint at Folsom Dam Powerplant.

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MEASURING FLOW RATE THROUGH CANAL CHECK GATES

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Western Water and Power Solution Bulletin No. 40

What Is The Problem?

Irrigation canals have typically been operated to maintain steady water levels in each canal pool. However, to improve water delivery efficiency, today operators are often asked to also control flow rates at key check structures. Typically, this requires constructing dedicated flow measurement structures or purchasing flow metering equipment—often at significant cost.

What Is The Solution?

When dedicated flow measurement devices are not practical, canal regulating gates themselves can be calibrated to serve as flow measurement devices. However, traditional gate calibration methods have had poor accuracy in some flow conditions. Now, new software is improving the accuracy of flow rate calibrations for both radial gates (also called tainter gates) and vertical slide gates commonly used to regulate large irrigation canals.

Laboratory testing has led to improvement of the calibration methods incorporated in the new software, increasing flow measurement accuracy for several challenging flow conditions:

- Transitional and submerged flow
- Gates discharging into downstream canals that are much wider than the gate itself
- Nonuniform operation of multiple gates located beside one another in a single check structure

With these improvements, the measurement accuracy obtained from calibrated gates can approach that of dedicated flow measurement devices. This saves money and also provides flow measurement capability to canal operators at exactly the most useful location in the canal system, the point of flow control.

Who Can Benefit?

The new WinGate software will be useful to operators of open-channel water delivery systems controlled by check structures containing radial gates or vertical slide gates. Gates may need to be improved by the addition of gate position sensors and upstream and downstream water level sensors, but, in many cases, this equipment is already installed. Some field investigations may be needed to account for the type and condition of the gate seals, which can affect the flow measurement calibration.

Check structure on the Amarillo Canal, Farmington, New Mexico.

Where Have We Applied This Solution?

Early versions of the WinGate software have been used during field testing for canals and radial gates on the Navajo Indian Irrigation Project (Farmington, New Mexico). Beta testers of the software have used it effectively on the Coachella Canal and the All-American Canal. Researchers in Spain have also applied the gate calibration method in WinGate (the Energy-Momentum, or E-M method) to vertical slide gates.

Future Development Plans

Recent laboratory scale model test data for radial gates are being used now to make further improvements to the Energy-Momentum calibration method, and those improvements are being incorporated into WinGate at this time. A journal article describing the latest work was submitted for review in the summer of 2011.

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Collaborators:

The Salt River Project co-funded this work.

Repairing Leaking Expansion Joints at Reclamation Facilities

by Kurt F. von Fay and Westin T. Joy, Technical Service Center's Materials Engineering and Research Laboratory Group

Introduction

Building on the Materials Engineering and Research Laboratory Group's (MERL, 86-68180) expertise in chemical grouting methods and materials, the group recently completed a number of repairs to leaking expansion joints. A variety of polyurethane chemical grout materials was used to successfully stop water leaks through several hundred feet of expansion joints. There are hundreds of formulations of polyurethane grouts, and many are formulated to stop water leaks or water movement.

Repairs were performed on the Folsom Dam Powerplant deck (figure 1), the Grand Coulee Pump Generation Plant deck (figure 2), and the Davis Dam Powerplant and transformer decks as well as vertical expansion joints below the transformer deck (figure 3) over about the last 12 months. The facilities were experiencing water leakage through expansion joints, leading to maintenance issues in the spaces below. At Folsom and Davis Dams, the water leakage was threatening electrical components in the powerplant. At Grand Coulee, the water leakage was affecting workers, materials, and equipment in the machine shops below the deck of the Pump Generation Plant.

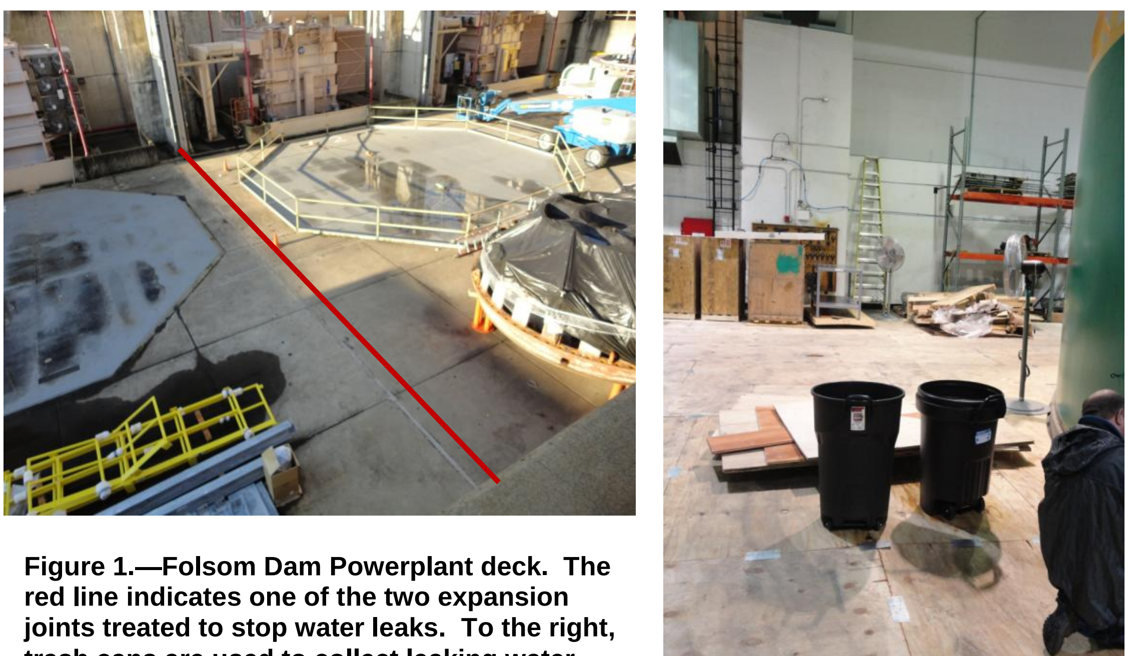

Figure 1.—Folsom Dam Powerplant deck. The red line indicates one of the two expansion joints treated to stop water leaks. To the right, trash cans are used to collect leaking water.

The specific reason that the joints started to leak is unknown. However, we saw evidence at Davis Dam that the joint compound and the cork board were badly deteriorated in some areas. In other areas, there may be a combination of failing membrane waterproofing and existing rock pockets or poorly consolidated concrete that allows moisture to eventually move around the waterstop. During injection work at Folsom, we observed stagnant water being pushed out of the joints by the expanding grout. We also observed several locations where grout easily flowed out the bottom of the joint, indicating there was a path around the rubber waterstop in some locations.

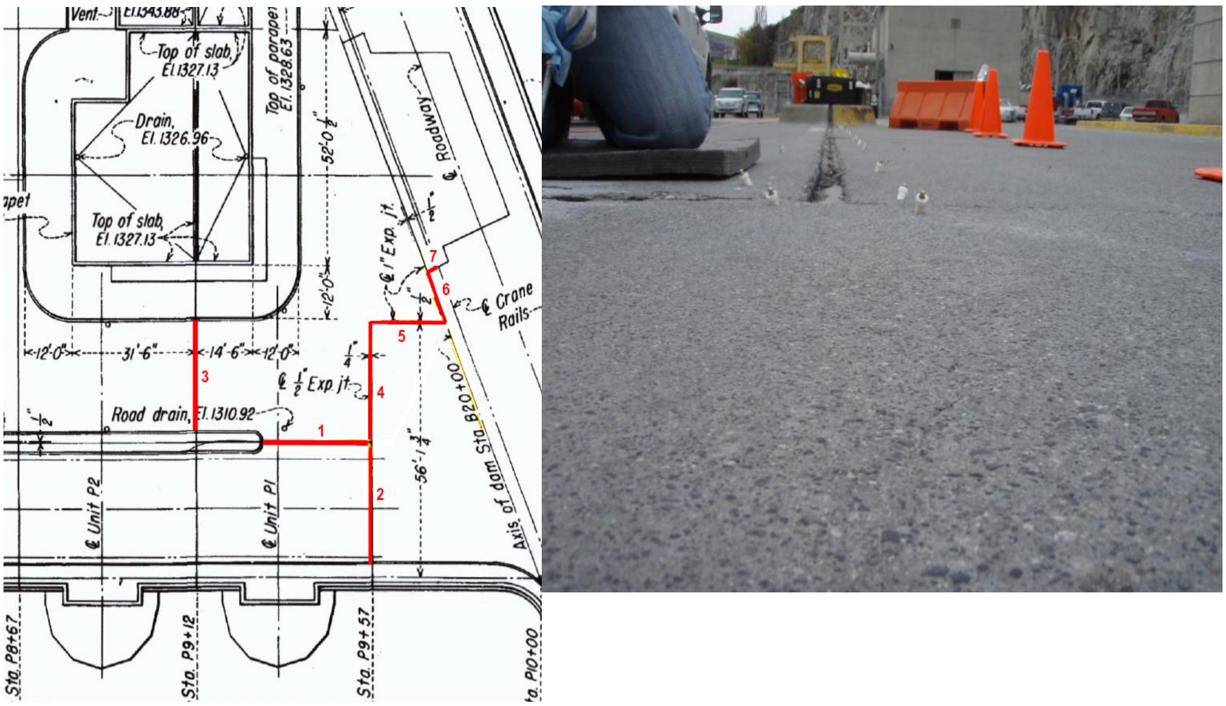

Figure 2.—A portion of Grand Coulee drawing 222-D-11209 showing the Pump Generation Plant deck joints that were grouted and line 1 with grout ports and zerks installed.

Repair Method

Many of our facilities are built with a common expansion joint detail (figure 4). While this detail looks like it should last essentially forever, many of our facilities are experiencing leaks through these joints. MERL was first approached about trying to find a way to prevent leaks thought the expansion joints at Folsom Dam Powerplant by Peter Funkhouser after he took our Concrete and Concrete Repair class. Previously, staff at Folsom had tried to repair the leaks by replacing the joint compound and rubber joint strip. However, the repairs appeared to have been short lived.

Figure 3.—A typical expansion joint on the transformer deck before repair at Davis Dam and repairs being performed below the transformer deck.

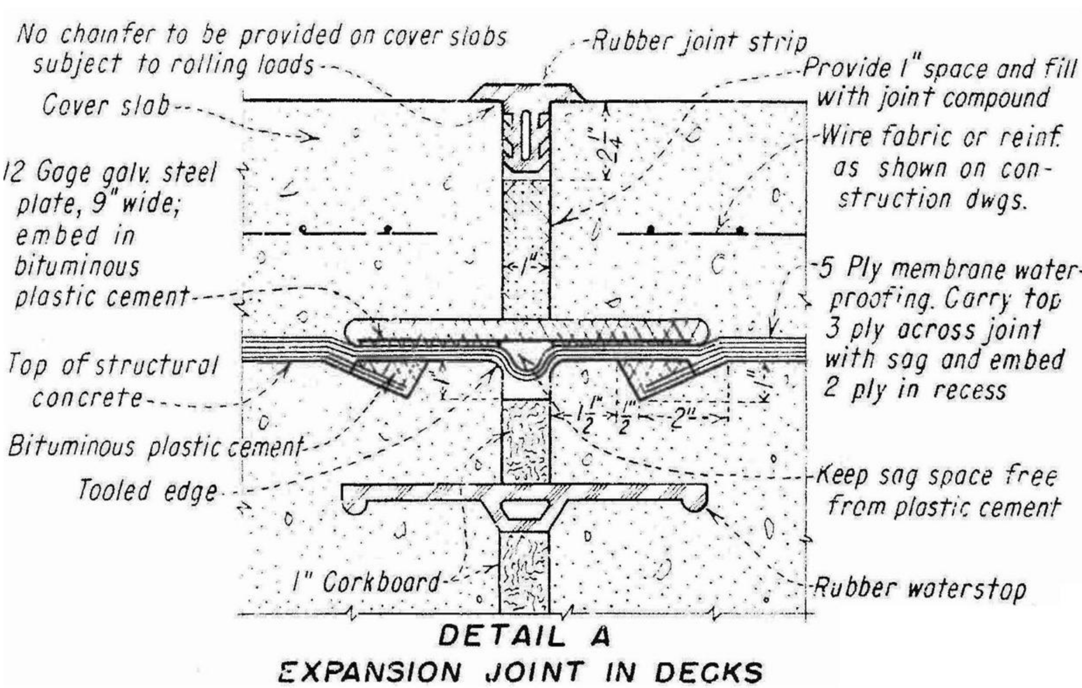

Figure 4.—Typical expansion joint detail.

The first step to determine the best way to repair the joints was to create a 3-D cross-section drawing of a typical expansion joint at Folsom Dam Powerplant (figure 5). We decided to do this to capture all of the relevant information about the joint, which included the position of the metal plate and water stop, the location of any formed drains that might be present, and the location of embedded steam pipes and asphalt grout channels in or near the joints. We needed to know this for several reasons:

- To determine the best place to inject grout
- To ensure that we could control where grout traveled during repairs
- To develop an adequate repair methodology, including material requirements, port locations, and port spacing

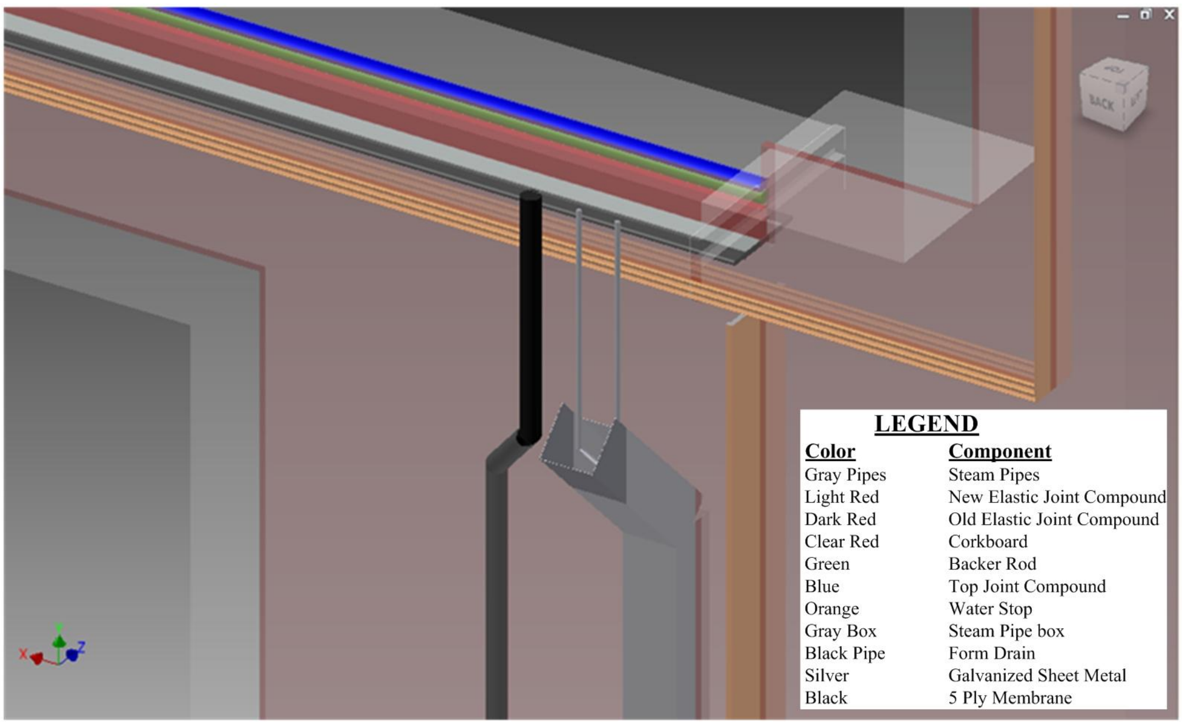

Figure 5.—3-D diagram of a typical expansion joint at Folsom Dam Powerplant.

After examining the joint details, we determined that the best approach would be to drill ports that were angled to deliver the grout between the top metal plate and the lower rubber waterstop (figures 6 and 7). The metal plate and rubber water stop would serve to help contain the grout as it expanded, which would result in a much more durable repair.

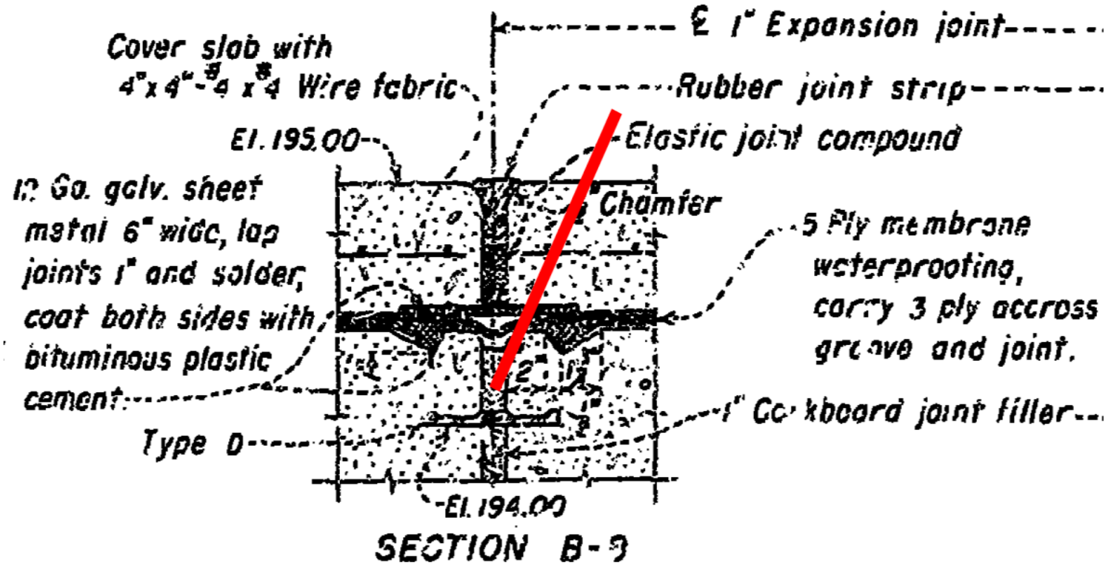

Figure 6.—Angled drilling holes as shown on joint detail from drawing 485-D-73 for Folsom Dam.

Figure 7.—Drilling holes for inserting grout injection ports. Holes were offset from the expansion joints and drilled at an angle to intercept the joint between the metal seal and the rubber waterstop. Note the change in color of the drill cuttings, indicating the cork board has been intercepted.

Since the majority of the grouting would be at relatively low pressure, we were able to use simple, plastic hammer-in ports (figure 8) for most of the work. After the plastic ports were installed, grease zerks were pushed into the open ends of the ports for attachment to the grouting assembly.

Figure 8.—This photo shows 3/8" plastic hammer-in ports used for chemical grout injection into one of the expansion joints and surrounding area of the Folsom Dam Powerplant deck.

Repair Material

A very important part of the repair was the selection of an appropriate repair material. Since we were injecting material into a joint, the material would need to be flexible. A material that would expand during and just after injection would help to ensure that repairs were watertight. We also needed materials that would start curing relatively quickly. In some exposure conditions, the repairs were likely to stay wet indefinitely. In other areas, the repairs would be subjected to hot, dry weather or cold, dry weather.

Because of these conditions and requirements, polyurethane grouts were selected for use. There are many types of polyurethane grouts to choose from. For most of the work, we selected a single component water-activated hydrophilic resin. These resins tend to cure relatively quickly and form a flexible foam product. For this type of work, these resins are usually mixed with equal parts water using special pumping equipment (figure 9). The resin and water are pumped separately to an "F-assembly" where water and resin are mixed just prior to injection (figure 10).

Figure 9.—Air-powered, two-cylinder pump that is pumping a single component polyurethane resin (left bucket).

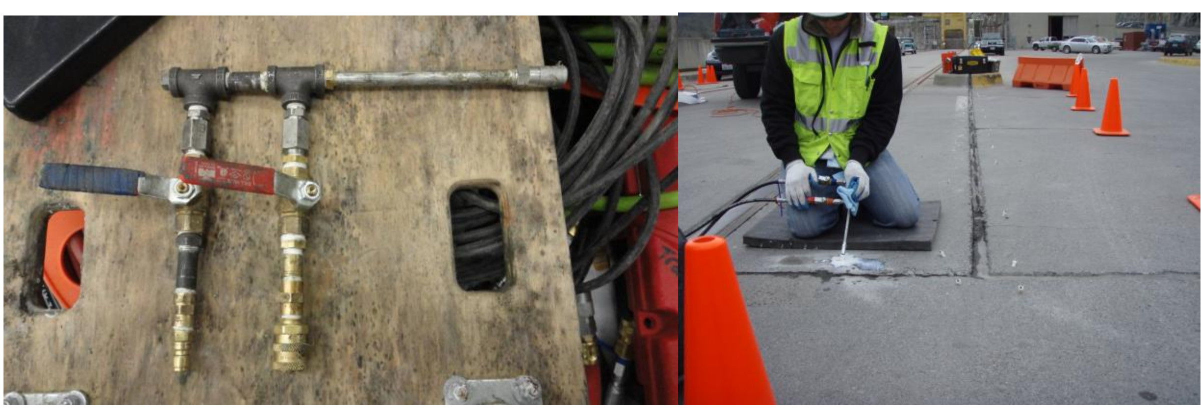

Figure 10.—A MERL employee injects a single component, water-activated polyurethane grout into an expansion joint of the Grand Coulee Pump Generation Plant deck. The fixture attached to a port is called an "F-assembly," which mixes the water and resin together.

For the hotter and drier exposure conditions, we used either a single component water-activated hydrophobic resin or a mixture of a hydrophilic and hydrophobic resins. Foams from hydrophobic resins are usually rigid, so we selected a formulation that resulted in foam that had similar flexibility characteristics to that of hydrophilic foams. Hydrophobic resins usually require a catalyst and react with a very small amount of water. To use these, water is usually injected into the joint first and then quickly followed by injection of the resin and catalyst mixture. We also occasionally used a mixture of hydrophilic and hydrophobic resins. We have experience with one manufacturer that makes a hydrophilic and a hydrophobic resin that can be mixed together at about a 4:1 ratio that results in flexible, tough foam. The mixed resins are then mixed with water at a 1:1 ratio just prior to injection.

Summary

Personnel from MERL have experience using chemical grouts to repair cracked and leaking concrete and leaking concrete joints. Using this experience, staff performed chemical grouting of expansion joints using single component, water-activated polyurethane grouts as well as multiple component polyurethane grouts. Subsequent rainstorms have proven the repairs to be successful, with no or significantly reduced leakage in the chemically grouted areas. Personnel from all three facilities have expressed their satisfaction with the work and are considering having MERL personnel return to perform additional chemical grouting on untreated joints in the structures.

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SEALING CONCRETE CANAL LINING USING AQUALASTIC MATERIAL

For approximately 15 years, Aqualastic (a polyurea sealing material) has been used by several Yakima, Washington, area irrigation districts to seal cracks, repair concrete spalls, and to seal panel joints. These irrigation districts (Ephrata, Roza, Kittitas, and Sunnyside) have repeatedly praised the performance of Aqualastic on their canal systems. Given their success in the use of this material, and after a tour of the Boise Project New York Canal and the performance of the material at that location, the Yakima Field Office (YFO) was determined to do market research for possible future Bureau of Reclamation (Reclamation) applications of Aqualastic.

Prior to 2008, the canal sealing process and procedures used by the YFO were by hand using a sand blaster along with polyurethane caulking or non-shrink grout. Today, in 2012, the YFO exclusively uses Aqualastic for its canal sealing needs. The Aqualastic crew comes from Water Storage Division within the YFO. The YFO has now been successful at sealing canal seepage areas and leaks for the past 3 years using the Aqualastic material. These applications have not only been performed in the YFO area, but also at neighboring irrigation districts and other Reclamation field offices.

As with many material coating applications, the application procedure starts with surface preparation. The concrete is media blasted with environmentally friendly 16 grit blast media to expose aggregate at an approximate depth of 1/16 to 1/8 inch. The area of repair is blasted to approximately 8 inches in width – 4 inches on each side of the seal or crack. Once a good aggregate profile has been achieved, the area is then high-pressure air blasted to remove any dust or particulates. If needed, excessive moisture or frost is removed by heating the surface with blow torches to "flash" dry the designated repair area. Occasionally, a second high-pressure air cleaning is needed to finish the panel preparation work. Surface preparation is essential to application success. This cannot be overemphasized because the product is a chemical bonding product, not a mechanical bonding one.

Once surface preparation is complete, the Aqualastic material is then applied. Currently, a high-pressure Graco HP3 Reactor is used, which is contained in a 20-foot-long enclosed trailer. The trailer also holds a 45-kilowatt generator to power the reactor. The Aqualastic material itself is a 1:1 ratio, plural component polyurea, which is purchased in 110 gallon sets (two 55-gallon drums.). The 55-gallon drums of polyurea are wrapped with heated drum blankets and must continuously maintain 90-120 degrees prior to and throughout the application process. The polyurea is applied at 2,500 pounds per square inch (psi) and 170 degrees at the application gun, which currently is a Graco Fusion MP. The current target for applied material thickness is 3 millimeters. The product has an exothermic reaction once it is applied, which last roughly for 8 seconds. Once the reaction is complete, the repair material is ready for service or to be watered up immediately.

This material has been applied in a variety of conditions, including high heat, extreme cold, rain, snow, and even sleet. Obviously, the better the weather conditions, the more favorable the application results. Colder conditions are harder for application because it is difficult to maintain the required hose heat of 170 degrees. Work can also be done in conditions with light precipitation where the water can be flash dried off. Heavier rain or snow conditions have forced the crew to focus more on prep work such as initial blasting and surface preparation.

The use of this material has been deployed to repair canals during the irrigation season while water deliveries are being made. For these situations, the product is ideal because the water level in the canal can be lowered to just below the repair area, and there is no need to completely shut down the canal system. Once the work area is exposed, the area can be prepared and the material applied in a timely and expedient manner with minimal water delivery interruption. The system can then be immediately returned to its full capacity.

Safety is always a high priority when applying this material. Air sampling was conducted 3 years ago in order to set the appropriate personal protective equipment (PPE) levels, and just recently, additional sampling was done to validate the required PPE. Respirators are required for the application process. Full face respirators were chosen for use because they give an added level of protection when media blasting is occurring in close proximity to the material application.

This Aqualastic material has specifications with an elongation of 867 percent, tensile strength of 3,400 psi, and a tear resistance to 400 PLI. With the high combination of both elongation and strength, this material is perfectly suited for bridging the thermal expansion and contraction cracks that our concrete canals have. In addition, once a backer is applied, this material can “bridge” holes of various sizes in the concrete lining of the canal system. As technology advances, there is a need to evaluate and consider altering our canal repair procedures. On average, the majority of Reclamation’s canal infrastructure is 80 years old. The old repair procedures of tar, grout, and tube application chemicals have been good, but they do not offer the potential longevity or the rapid completion time of these repairs. At this time, there are several canal systems in the Yakima area that have the early Aqualastic applications still holding well at 15 years of service. The expected service life of this material is still unknown; however, 25 years of service is currently not an unreasonable expectation.

Several benefits have been seen with the success of these Aqualastic applications. Several seepage areas on neighboring farm land have been eliminated, which now allows farmers to use the land as they had intended (i.e., crop or range land).

Eliminating water seepage also avoids the potential of panel failure or collapse due to erosion of the soils behind the panel. Additionally, one of the best benefits from these Aqualastic applications is that of water conservation. The sealing process helps to retain the water volume of the canal by eliminating water loss through seepage. Furthermore, the elimination of seepage has allowed the area powerplants to increase hydroelectric production output. This material has been used for the past 3 years to do repairs and maintenance on the Chandler Canal. In doing so, the power generation production has increased by 30 percent, which is a direct result of not needing to shut down for prolonged periods of time for maintenance during the winter months and reduced seepage and panel leakage.

Mission

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

The purpose of this bulletin is to serve as a medium of exchanging operation and maintenance information. Its success depends upon your help in obtaining and submitting new and useful operation and maintenance ideas.

Advertise your district's or project's resourcefulness by having an article published in the bulletin—let us hear from you soon!

Prospective articles should be submitted to one of the Bureau of Reclamation contacts listed below:

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