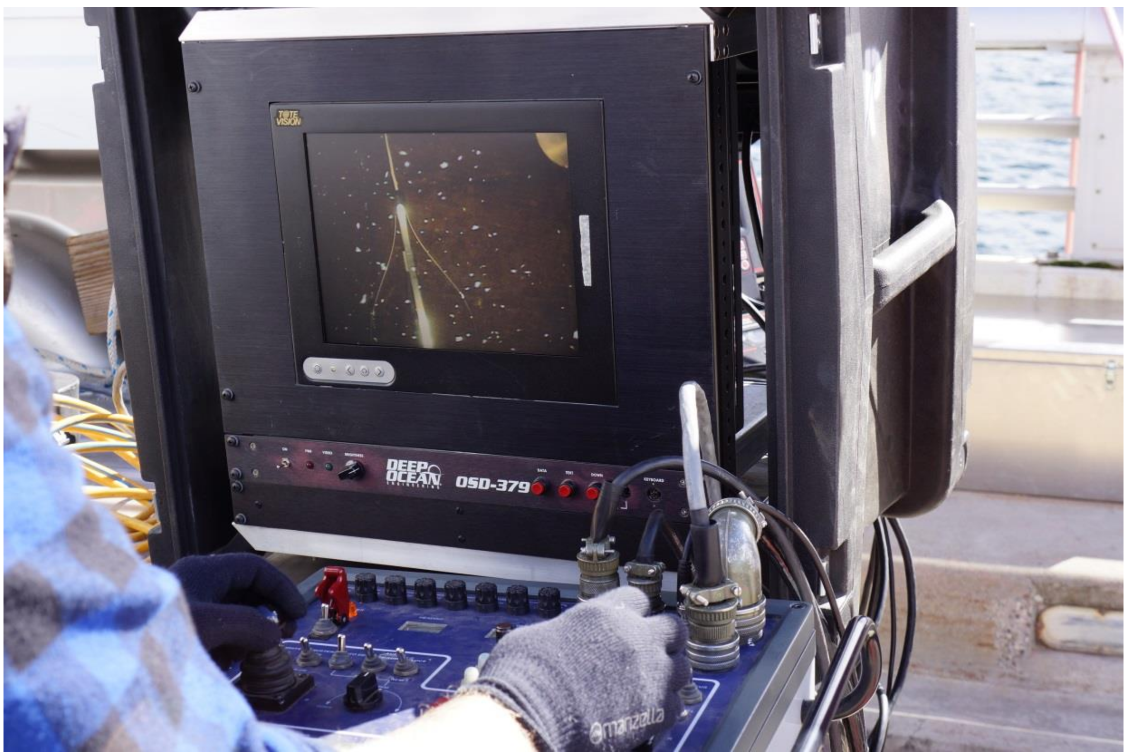
RECLAMATION

Managing Water in the West

Technical Memorandum No. MERL-2014-96

Sealing Leaking Contraction Joints

Science and Technology Project ID: 3191



U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Materials Engineering and Research Laboratory
Denver, Colorado

November 2014

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Sealing Leaking Contraction Joints Scoping Study
Science and Technology Project ID: 3190

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CONTENTS

Figures

Photos

INTRODUCTION

The Materials Engineering and Research Laboratory (MERL) conducted a scoping study to investigate methods for sealing leaking contraction joints. The study focused primarily on determining areas where further research would help improve methods and/or materials used in this type of repair.

BACKGROUND

Many of Reclamation's concrete dams were constructed with contraction joints that contain metal waterstops to prevent water leaks through the joints. While these waterstop materials worked well for many years, as the contraction joints flex and move, some of the waterstops are failing. In some cases when they fail, they can allow large amounts of water into galleries and equipment rooms within the dam, causing significant maintenance and safety issues.

Repairing failed waterstops in contraction joints has proven to be very difficult, expensive, and is usually not effective, or only effective for a short time. The most widely used methods for sealing leaks in concrete joints and cracks are placing chemical grouts – typically water-activated polyurethane grouts. They are in a liquid form, react with water, and form a foam end product. (A similar product would be the expansive foam sold in cans for sealing air leaks for home use.) These grouts have a range of reaction times and properties and have limited uses in high water flows. Some grouts can react rather quickly (within 10 seconds), creating a rigid foam end product that does not flex. If these rigid foams are placed in a concrete joint that moves due to temperature changes, they rapidly degrade and no longer seal the joint.

One method of repairing failed waterstops that has been getting some attention lately is the use of a hydrophilic rubber compound placed into holes cored behind the failed water stop. The method is expensive and cannot be used at all facilities. The product is called Cylutions, manufactured by Emagineered Solutions Incorporated. Typical use involves:

- Drilling a vertical core hole, usually about 6 inches in diameter, in a leaking contraction joint near the upstream face of a water control structure.

- Dropping sections of the product (usually about 3 feet long) into the core hole in the form of solid cylinders.

This product is a solid urethane that reacts with water and can expand to completely fill the core hole and seal the leaking joint (photo 1).

Photo 1.—A section of cylindrical Cylutions waterstop being placed into a core hole.

Grand Coulee Dam has a contraction joint (block 81/82 joint) where the leaks have been steadily increasing. Numerous methods have been investigated to slow or stop the leaks, including using Cylutions. However, using the product in the large tube form was not practical at Grand Coulee. We needed something small enough to be placed into small concrete joints without first coring a hole. We worked with the manufacturer and received a ground up version of the product (photos 2 and 3). We noted that the smaller ground up particles reacted much faster than the larger particles.

Photo 2.—Ground up waterstop. The left side shows the product before contact with water and the right side right shows the product after water was added. The cups contain the same volume of waterstop material.

Photo 3.—Ground-up version of Cylutions waterstop.

Our plan was to place this ground up form of the material into the reservoir near the upstream face of the dam close to the joint, and use the flowing water to carry these small particles into the joint. Once the particles were in the joint they would react with the water, expand and seal off the joint.

Once we received the product it was too large for our applications (see photo 3). In order to create smaller particles, we ran it through a meat grinder. Figure 1 shows the gradation of the particles.

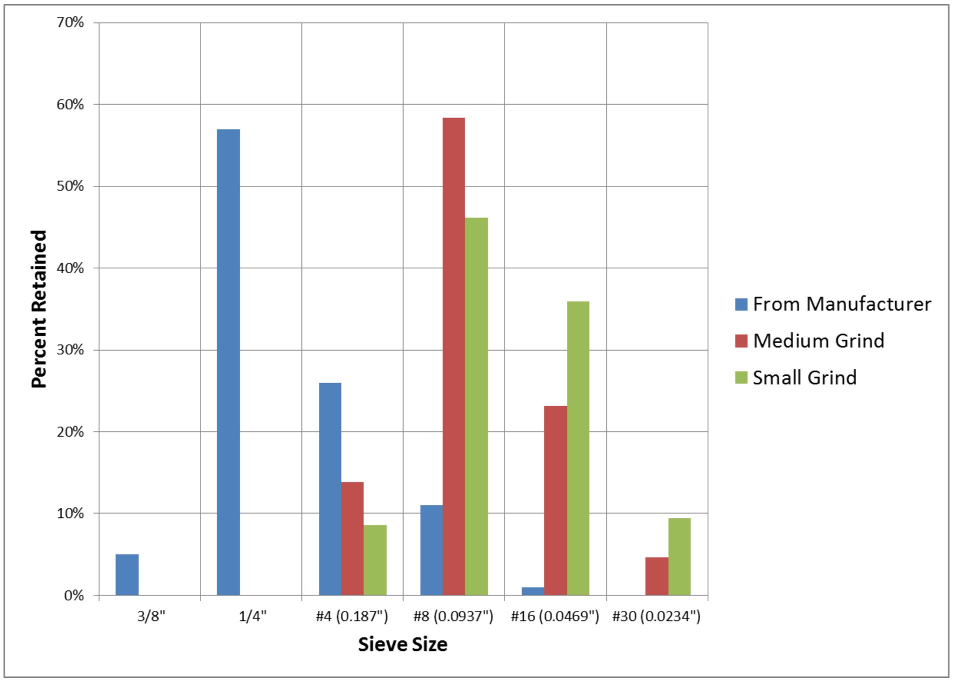

Figure 1.—Gradation of waterstop from the manufacturer and after meat grinder.

CONCLUSIONS

Placement of the ground up waterstop was a success. The waterstop was placed from the top of the dam without the need for divers, using video cameras, a pump, and piping.

The waterstop infiltrated the joint well, slowing the water flow from 150 to 63 gallons per minute (GPM). This slowed the water enough so that interior chemical grouting could be performed successfully.

The particles did not completely seal the water as hoped. Small pathways through the particles allowed water to continue to flow at a reduced rate. Further research needs to be conducted to seal up these small pathways. This could be accomplished by either getting the particles stick to each other or creating a finer material to better fill in these voids.

The delivery method used required the particles be suspended in water for about 5 minutes while they were pumped down the tubing to the joint. This time was longer than desired and caused some of the finer particles to be completely expanded before they reached the joint. Further research needs to be conducted into a method for placing the particles at the joint with minimal expansion already taken place.

The 81/82 joint that was sealed is in close proximity to a hydropower generating unit. Sometime after the particles were placed the unit started operation, and the water flows increased. The vibration from the generator likely dislodged some of the particles, and they were then forced through the joint. Further research needs to be conducted to make this repair method more of a long-term solution.

DISCUSSION

We have previously worked with personnel at Grand Coulee Dam in Washington to stop other leaks. Attempts have been made to seal up a leaking joint between blocks 81/82 using chemical grouts. These attempts have been marginally successful due to the high flows of water (about 150 GPM) this joint sees.

Grand Coulee (GC) personnel ran a video camera down the upstream face of the dam using plastic pipe and observed water infiltrating the 81/82 block joint. They could see small particles flowing into the contraction joint between the 1060 and 1030 elevations. The bottom of the joint was at the 1018 elevation, and the top of the dam was at an elevation of 1290.

A dye test was also performed on the upstream face. Dye was injected into the reservoir on the upstream face while personnel were inside galleries watching to see where the dye infiltrated and how quickly it entered the galleries. The dye took between 3 and 5 seconds to travel from the reservoir into the galleries. Additional dye was injected along the entire face to get a better idea of where the water was entering the dam. As was observed with the camera, they found water entering between the 1060 and 1030 elevations, and any dye injected below the 1020 elevation pooled on the bottom of the reservoir.

Because the water was flowing from the reservoir into the galleries so quickly, chemical grout was not a suitable repair method, as it would not cure fast enough. Most flexible chemical grouts have a set time greater than 20 seconds.

We had several conference calls with GC to discuss a suitable repair option. They had tried a few different methods with limited success. In one attempt, they placed a small diameter flexible hose in the reservoir over the section of joint between the 1060 and 1030 elevations and allowed it to be sucked into the joint with the flowing water. Due to the roughness of the joint, there was only minimal reduction in flow as measured by a weir placed in the drainage ditch in the 1000 elevation gallery (photo 4). They also placed a plastic membrane over the upstream face on the same section of joint and allowed it to be sucked over the contraction joint. This membrane pressed onto the face well; however, the flow did not decrease. A likely explanation for this was that water flowed into the joint from above and below the membrane, since the membrane did not seal the joint at its ends.

Photo 4.—Weir placed in the 1000 gallery drainage ditch measuring inflow coming from the 81/82 joint area.

Based on this information, we developed a plan to try another approach to sealing the leaks. We felt that the ground up waterstop could be pumped to a location very close to the leaks using plastic pipe and observing results with a camera. One major advantage of this method, if it worked, was that the work could be done at great depths without using divers. Placement methods were first tested at MERL, and then a site test was performed with GC personnel.

FIELD APPLICATION

The ground up waterstop was placed in a 55 gallon barrel with water, and an agitator was used to keep the particles suspended (photo 5). This slurry was then pumped from the top of the dam through one inch plastic tube using a screw type progressive cavity pump (photo 6). The distribution of the slurry was monitored by GC's remotely operate vehicle (ROV) (photo 7) and a downhole inspection camera (photo 8). The hose location was controlled from the top of the dam. It was raised and lowered so the outlet was close to the joint and in a place where water was actively infiltrating. A section of steel pipe was attached to the underwater end of the hose to keep it submerged and make it easier to control.

Photo 5.—Ground-up waterstop suspended in water.

Photo 6.—Progressive cavity screw pump used to deliver water/waterstop solution.

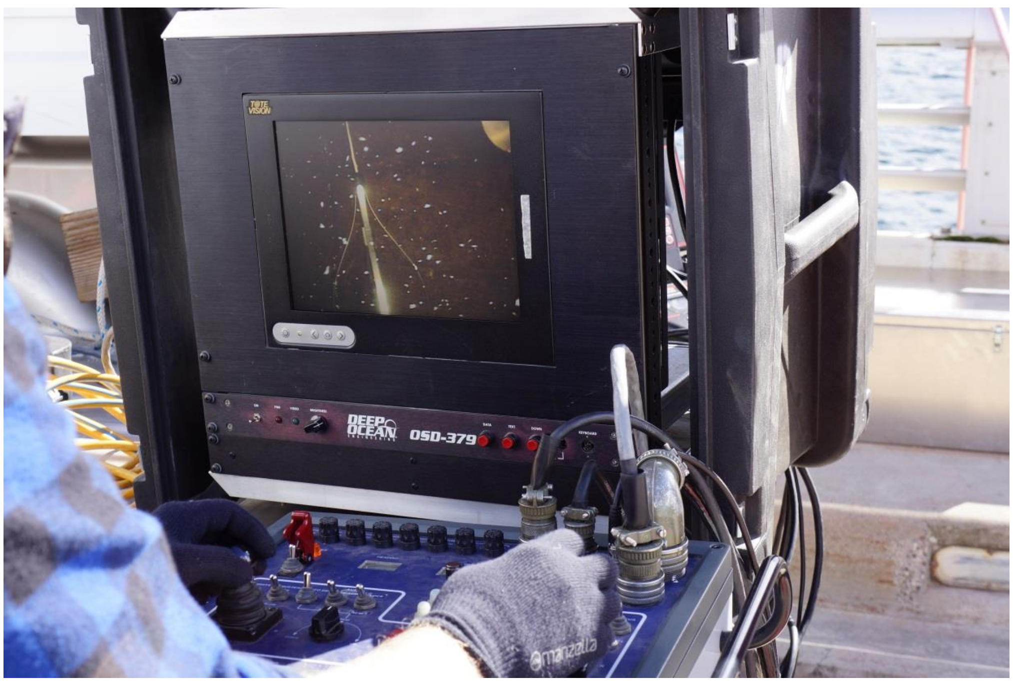

Photo 7.—Grand Coulee's ROV mointoring the waterstop placement.

Photo 8.—Grand Coulee personnel monitoring waterstop placement with a well camera.

Photo 9.—Waterstop material packing on the front and entering the joint.

On day one, the 1000 elevation gallery flume read 0.44 foot, which corresponds to a flow rate of 145 GPM. A total of 40 lbs. of ground waterstop was placed between the 1060 and 1030 elevations. At the end of the day the flume read 0.36 foot (100 GPM). The smaller waterstop particles entered the joint while the larger waterstop particles packed on the front of the joint (photo 9).

The next morning, the level in the flume was the same as the previous evening (0.36 foot or 100 GPM). An additional 50 pounds of product was mixed and placed at the 1060–1030 elevations before noon, resulting in a flume reading of 0.30 foot (71 GPM). At this point the face of the joint between the 1060 and 1030 elevations was almost completely full of particles, to the point where the particles were beginning to create a mound at the joint (photo 10). That afternoon 10 more pounds of ground waterstop was mixed and pumped, mainly into a couple of holes where the mounded up particles had been sucked into the joint. At the end of the day the flume reading was 0.28 foot (63 GPM).

Photo 10.—Waterstop material creating a mound on the face of the joint.

On the third day, a small amount of waterstop was pumped to fill a few more holes that had developed overnight. Additionally, the hose was moved completely up and down the joint to fill in any additional unseen leaks. No leaks of any significance were found. Small amounts of waterstop particles traveled completely through the joint and were seen in the drainage ditch in the 1000 gallery.

After followup discussions with GC personnel, we learned that the leaks had increased. They noted that the increases seemed to occur after running the generator in close proximity of the leaking joint. It also increased as the temperatures decreased.

Based on these results, it seems that modifying the material so that it becomes sticky, or mixing the particles with other polyurethane resins might improve performance. In addition, using smaller particle might improve performance. Finally, very little is known about the actual physical properties of the material. Further testing of this product to better characterize its physical properties would also be helpful.