

Moyie Dam Repair: Back to the Future

By Mike Newcomb and Leo Waddell



Fig. 1: Prep Training at Moyie Dam, 1981.

GOING BACK TO MOVE FORWARD

Moyie Dam at Bonner's Ferry in northern Idaho started initial construction just before WWII. They shut down construction during the war. After the war was over, the dam went into service in the late 1950s.

The dam is hydroelectric, and the dam's surplus electricity is purchased by Seattle Light—Washington's electric company. After running high-velocity water down the spillway for decades, by 1980, the concrete was significantly deteriorated and needed to be rehabilitated.

In 1981, Leo Waddell won a bid to resurface the first half of the spillway with an epoxy grout. Leo bid on the job based on the Engineer's requirements. Leo then got together with the Engineer and showed him that the epoxy specified had major bonding problems – it was de-bonding. Leo demonstrated that by tapping the epoxy with a hammer, there were many hollow, delaminated spots. Leo convinced the Engineer that shotcrete was the best solution for the spillway rehab. They did a mockup test with a

gunitite (dry-mix shotcrete) machine and showed the Engineer that with shotcrete, there were no hollow spots—it was 100% bonded. After that, a change order was processed to switch from epoxy to shotcrete. Because there were only about two or three months a year that the dam's spillway was without water, the project needed to be split into two separate "dry seasons." Leo got the contract to do them both: the first half in 1981 and the second half in 1982.

As a consultant on the Moyie Dam Rehabilitation in 2021-22, this project recently took Leo back to the future!

In 1981, Leo and his crew used a REED LOVA model dry-mix shotcrete machine to spray the material. The mixture was extremely simple by today's standards – just four parts sand and one part Type II cement. The mixture was batched on the job site

with a continuous-feed mixer with a vane feeder that Leo built. Leo used a 750 CFM Gardner Denver air compressor to blow this material through a 2 in. (50 mm) gunitite hose to get to a REED 2 in. liner style, Hamm nozzle. Leo used an air-driven water booster pump to get approximately 100 psi (0.7 MPa) of water pressure. They also used the high-water pressure water to wash the rebound down the slope and right into the river. Consulting on the job in 2021, Leo acknowledged that, "you can't do that no more."

On the original resurfacing job in 1981, Leo built his own scaffold; it had skids on it, it was about 10 ft (3 m) wide, and there was a winch down at the bottom of the dam to help move the scaffold. They had an 8 in. (200 mm) diameter pipe up on top of the dam that gravity-fed the mixed material down to the bottom of the dam. They shot everything from the bottom to the top, which was roughly 100 ft (30 m) up the spillway. The spillway and the three training walls between were the only parts of the dam that needed to be rehabilitated because it is the force of the fast-flowing water that deteriorates the spillway surfaces.



Fig. 2: Prep at Moyie Dam, 1981.



Fig. 3: Moyie Dam completion, 1982.



Fig. 4: Right spillway at Moyie Dam showing old shotcrete, 2021.

FAST FORWARD TO THE FUTURE

Nearly 40 years have passed since that original rehabilitation project, and Leo got a unique chance to go back and work on it again. In 2021, the very same spillway was once again in need of repair. So, the project was put out to bid. Leo got a copy of the plans on the bid. Once again, they wanted to use epoxy. Leo met with the Engineer and once again insisted that the bonding agents must be removed from the bid. Leo said, “On shotcrete, we don’t use bonding agents—no epoxies. With shotcrete, ASA and ACI have



Fig. 5: Left spillway at Moyie Dam showing old shotcrete, 2021.

shown that bonding agents are not only unnecessary, but they also cause failures.”

S & L Underground, out of Bonners Ferry, ID, was awarded a new contract for 2021 and 2022. Leo was hired as a consultant by S & L on the new project, and he found about 70% of the previously placed shotcrete on the spillway was still in good shape. Both dry-mix and wet-mix shotcrete were considered for the new repair. Part of the reason for selecting dry-mix was the excellent performance of the previous shotcrete. Most of the new deterioration was found to result not from the shotcrete but from the low strength in the original 1940s and 1950s concrete. In the 1980s repair, they used chipping hammers to locate and tear off any concrete that was loose, sandblasted it, and then shot new the shotcrete.

In 2021, S & L Underground used hydro demolition to prepare the surface. They found, when they tried to hydro demo much of the 1980 shotcrete repairs, it was so hard that they left portions of it in place because the hydro blaster was taking too much time to remove the structurally sound concrete.

The material and logistical situation in the 2021 rehabilitation was quite a bit different than the 1981 repair except for one thing. Just like in 1981, in 2021 a REED LOVA model dry-mix shotcrete machine with 2 in. hose and nozzle and a 15-pocket standard bowl was used. This time, instead of Leo’s handmade mixer, the contractor bought a new Canusa model PDM-1 continuous pre-dampener/mixer with an integrated tote bag holder for the 3000 lb (1400 kg) super sacks of dry concrete material. The PDM-1 uses an electric motor powered by a diesel generator.

The dry-mix material used on this job was significantly more sophisticated than the rehabilitation in the 1980s. The material was pre-batched by Oldcastle in Spokane, WA. Leo worked with Oldcastle to design the mixture. The mixture was 41.5% coarse sand, 26.5% fine sand, 22.8% Type II



Fig. 6: Hydro demolition at Moyie Dam, 2021.



Fig. 7: Bulk bag hanger at Moyie Dam, 2021.



Fig. 8: View of equipment staging at Moyie Dam, 2021.

cement, 7.6% pea gravel, 1.7% silica fume, 0.02% Master Builders M100 fibers, and an air-entraining agent. When field tested, the mixture as-shot had 5% air content. Overall, this mixture was much better than the 1980s mixture with higher strength and entrained air for freeze-thaw durability.

They used 3000 lb super sacks. Each sack contained the following:

- Ash Grove cement 685 lb (311 kg)
- 1244 lb (564 kg) coarse sand
- 792 lb (359 kg) fine sand
- 239 lb (108 kg) pea gravel
- 50 lb (23 kg) silica fume
- 0.5 lb (0.23 kg) of fibers
- 27 to 34 oz (0.77 to 0.96 kg) of powdered air entraining admixture

In 2021, the contractor had the predampener and dry-mix shotcrete machines set at the top of the spillway. They used a crane on site to move the scaffolding, the hydroblaster, and super sacks of dry-mix material. During the second phase of the project (2022), they put the dry-mix machine down at the bottom of the spillway just as Leo had done in the 1980s.

Other than the fancier mix design and much more expensive on-site equipment, Leo said that biggest difference from the 1981 rehab to the 2021 rehab is that in 1981, Leo put on a layer of shotcrete that was between 2 to 6 in. (50 to 150 mm) thick. For the new 2021 rehab, the contractor added #4 (#13M) reinforcing bars spaced at 10 in. (250 mm) on center and applied shotcrete from 6 to 12 in. (150 to 300 mm) thick. Leo thinks with the addition of the reinforcing bars, the thickness of the shotcrete, and the more sophisticated dry-mix material used, the spillway's strength should easily still be good the next time he visits the dam in another 40 years.

Leo Waddell's legacy in shotcrete spans over 60 years, and the work he has done with the Moyie Dam has bridged an impressive gap of 40 years. This project is a celebration of not only his career-spanning commitment to shotcrete as a placement method, but to his present-day commitment to the industry and to the next generation of its leaders.



Fig. 9: Nozzlemen placing and finishing new shotcrete at Moyie Dam, 2021.



Fig. 10: Continuation of shotcrete placement at Moyie Dam, 2021.



Fig. 11: 86 years young—Leo shooting a pool wearing his signature cowboy-style hard hat.



Leo Waddell is a legend in the shotcrete world. Leo's now 86, and he has been around wet-mix and dry-mix shotcrete for most of those years. In 1960, Leo was hired as a finisher to work with a crew and shot two pools in one day with an Allentown Double Chamber Gun at the Grand Cooley Dam.

In 1964, Leo shot a pool for the State of Nevada—a girl's school operated by the State. It was about this time that Leo met Frank Reed, inventor of the bowl-type dry-mix (gunite) machine. Mr. Reed showed Leo a prototype for an automated, double-chamber pressure vessel with valves to operate it that he had had never moved forward with.

One of the more unique shotcrete projects that Leo came across was in the U.S. Military's Pregondola 1 project in 1966 and 1967. Dry-mix was used to build seven underground structures in Montana as a way to test the idea of using nuclear explosives to "dig" a new Panama Canal wide enough to sail aircraft carriers though. In the test in Montana, they used alcohol to simulate a nuclear explosion. Later, an actual nuclear explosion was performed in the Aleutian Islands near Alaska, but because the military identified a major problem in the nuclear fallout, the military's "nuclear digging" plan was scrapped.

Even at 86, Leo is still getting his hands dirty. As a consultant, Leo still flies out to help people set up job sites, to suggest materials and equipment, and to train nozzle men.

2023 HONORABLE MENTION

Project
Moyie Dam Repair
Project Location
Bonner's Ferry, ID
Shotcrete Contractor
S & L Underground
Shotcrete Consultant
Leo Waddell, Shotcrete Consulting
Materials Supplier
Oldcastle Precast
REED Concrete Pumps
General Contractor
S & L Underground
Project Owner
City of Bonner's Ferry, ID



Mike Newcomb is the Sales and Marketing Manager at REED Shotcrete Equipment. Mike holds a B.A. from UCLA and an M.B.A. from Cal State Fullerton. Mike started at REED in 1997 and enjoys working with REED's dealers and customers. REED is a privately held, American-owned company that has been manufacturing concrete placing equipment in California since 1957 when Frank Reed invented the bowl-type "Guncrete" Gunite Machine. REED has a worldwide network of well-qualified Official Dealers who are experts in shotcrete equipment and are responsible for all on-site startups, after-sales service assistance, and parts assistance.