# Tieton Dam Spillway Rehabilitation

*by Larry Totten*

Johnson Western Gunite Company rose to the challenge of rehabilitating the Tieton Dam Spillway in Yakima, WA. The spillway, built originally in 1924, was showing significant deterioration due to freezing and thawing, weathering, and erosion due to high-velocity water flow. The owner, the United States Department of the Interior Bureau of Reclamation, designed a repair consisting of a 12-in.-thick (300 mm) reinforced, cast-in-place concrete overlay on the floor and left wall if one was looking downstream. The budget in the original contract was not sufficient to overlay the right wall.

The biggest obstacle facing the contractor in the spring of 1998 was the condition of the adjacent rock face that is approximately 400 ft (120 m) high. The steep surface required scaling, rock bolting, rock fall, and other safety measures such as guardrails to protect the workers in the spillway from falling rock. Working in an active spillway at approximately 3000 ft (915 m) above sea level in eastern Washington State made this project challenging to say the least. Braving the snow, wind, and frigid conditions every day were a crew led by general superintendent Fred Harvey and concrete superintendent Doug Douglass.

In the first construction season, the rock scaling work increased in magnitude from what had been anticipated in the bid documents and prevented any work from being done in the spillway until early September. By late September, the night-time temperatures were already between 20 and 40 °F (–7 °C to 4 °C). Temperatures that low require cold-weather procedures for the concrete placements for the floor slabs. A large section of the spillway was on a 23.3% grade, which made concrete floor placements very difficult. Access was limited along the spillway for concrete pumping and bucketing. Along the 1400 lineal feet (425 m) of spillway, the only access for concrete pumping or bucketing was at approximate stations 5+00 and 13+00. The owner required a 1-1/2 in. (37.5 mm) maximum size aggregate in the floor concrete.

The contract specification clearly stated that the concrete wall overlays were to be placed using conventional, formed and poured, cast-in-place concrete. The contractor requested to change the

*Figure 1: Partially completed spillway overlay showing scaffold system, alternate panel construction, and wet curing.*

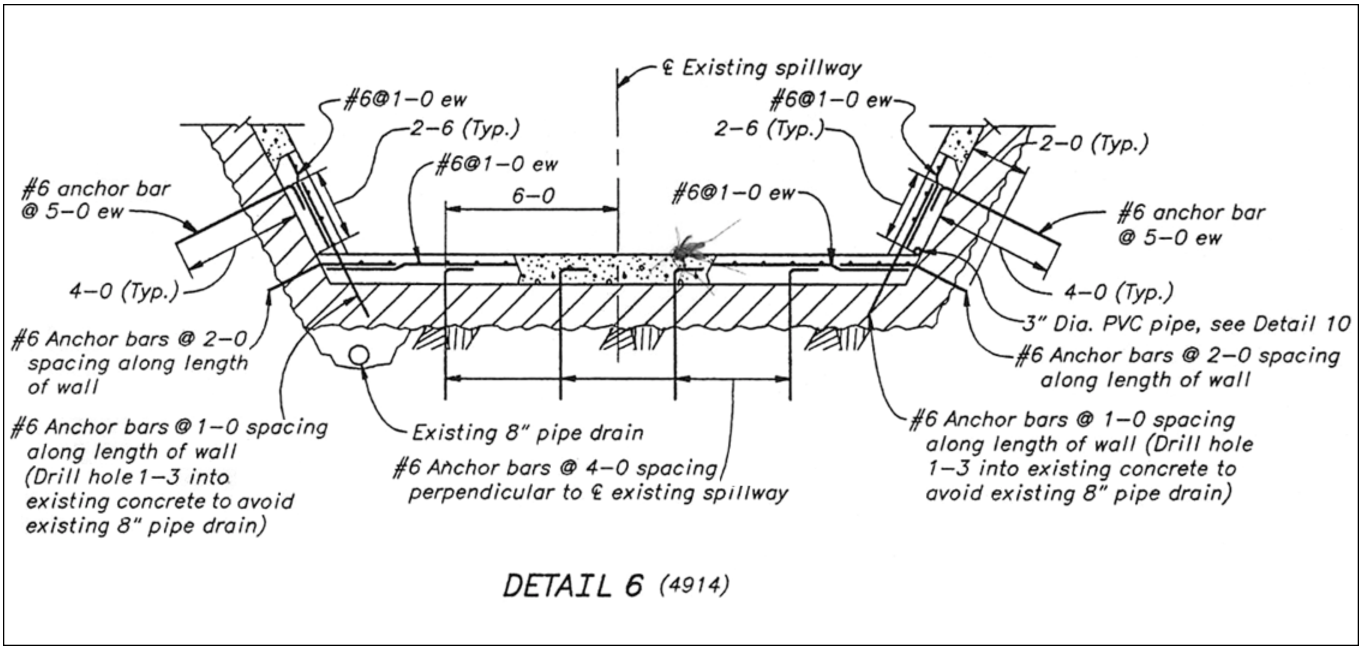


*Figure 2: Detail of reinforcing and anchors.*

placement method to wet-mix shotcrete placement as a cost-saving method. The owner was initially reluctant to accept this change. The local office of the Bureau was, however, supportive of the change due to their prior experience with shotcrete and the relationship that had been developed with the contractor. The technical staff at the headquarters was more skeptical. They questioned whether shotcrete could be placed in this type of structure to the quality required to last under the harsh weather and significant number of freezing-and-thawing cycles that were experienced in this location. The quality of finish achievable was also questioned as compared to formed concrete. They conducted significant research and engaged a consulting firm, Agra Earth & Environmental (now AMEC), to help evaluate the proposal and ensure that they could get a high-quality overlay comparable to standard cast-in-place concrete. The contractor provided the owner with significant references and test results from past projects. It was finally agreed to construct a full-size mockup in the spillway at the end wall at the upper end of the spillway where there was no significant water velocity. This mockup was completed late in the first season. The mockup was successful from the standpoint of shotcrete quality and the finish required. With the results of this mockup, the information from past projects, the recommendation from the consultants, and the support of the local office in conjunction with other research, the owner agreed to allow the shotcrete value engineering alternative for the wall construction.

The owner required a detailed cost proposal to address the cost in the contractor's original bid for the cast-in-place concrete as compared with the proposed shotcrete alternative. The cost savings were significant. The owner decided to not only allow shotcrete to be used for construction of the left wall, as included in the original bid, but also requested the contractor to use shotcrete to construct the overlay of the right wall at the same unit prices proposed for the left wall. The contractor agreed, and the owner was able to complete the overlay of both walls and the floor for slightly more than the original bid for the floor and left wall only.

The decision to allow shotcrete was based on a stringent specification, preconstruction certification and qualification of nozzlemen for the project, and consistent high-quality installation of shotcrete in the spillway. Agra Earth & Environmental was hired jointly by the owner and contractor to conduct the preconstruction nozzleman certification and quality-control orientation. All inspection personnel, along with the contractor's staff, participated in this program.

All nozzlemen who were proposed to be used on the project had to successfully complete a written and performance test. The performance mockup contained similar reinforcing as the actual spillway and included the encapsulation of a water-stop. All of the contractor's proposed nozzlemen passed these tests and were qualified for the project.

The owner assigned a full-time inspector to the project to monitor the shotcrete placement and testing. An unreinforced test panel was shot for each 50 yd$^3$ (38 m$^3$) of shotcrete placed, and these test panels were cored for compressive strength testing. Cores were also taken from the

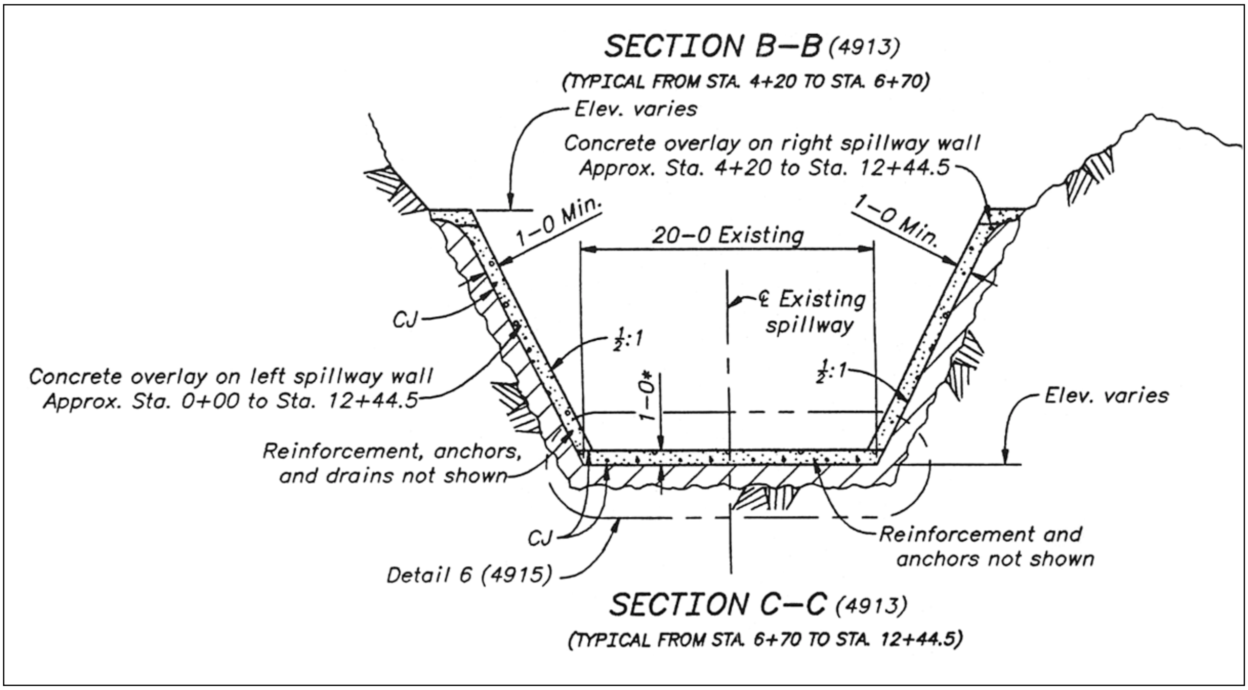


*Figure 3: Cross section of spillway.*

in-place work to verify good encapsulation of the reinforcing steel and the PVC waterstop at each vertical joint. All completed work met or exceeded the owner's requirements.

The owner required the placement to be done in an alternate panel sequence, for the placement to be in approximately equal length to height panels, and a minimum of 4 days between adjacent panel placements. The scheduling of the shotcrete placements was complicated due to this requirement.

The shotcrete mixture design was a relatively simple 4000 psi (27.6 MPa) pea gravel pump mixture. This mixture consisted of a 7.5-sack mixture (705 lb/yd$^3$ [420 kg/m$^3$] of cement) with 30% pea gravel and 70% sand with air entrainment to resist freezing-and-thawing damage. Due to the remote location, a retarder was used to increase the amount of time allowed between batching and placement. Concrete deliveries were carefully scheduled to ensure that all concrete was placed within the manufacturer's suggested time.

When the second season came along, water control measures were needed as water was flowing through the spillway. The water had to be diverted away from the wall under construction and the effluent had to be filtered to ensure that no contamination occurred in the river downstream of the spillway. The volume of overflow water and the numerous water sources were not conducive to containment in a pipe. The contractor set up a series of diversions to direct the water away from the area under construction. These diversions were moved as required to change work areas. A series of filtering basins were set up to remove any contamination from the concrete operations before the overflow water was allowed back into the river.

In addition to placement of concrete, the project also required removing and reinstalling an existing rock debris fence; torquing, tightening, and painting existing rock bolts; drilling holes and installing steel pipe for anchorages; preparing the surface of the left spillway walls spillway chute floor, and the stilling basin floor; hydroblasting stairs and the deck; and excavating the existing concrete.

The project was not small by any means. The final contract amount was just under $3 million. A total of 80,000 ft$^2$ (7400 m$^2$) was overlaid (30,000 ft$^2$ [2750 m$^2$] of floor and 50,000 ft$^2$ [4650 m$^2$] of wall) by 2300 yd$^3$ (1760 m$^3$) of shotcrete and 1200 yd$^3$ (920 m$^3$) of cast-in-place concrete. Additionally, the project required 175 tons (160 tonnes) of rebar and 20,540 ft (6260 m) of drilled and grouted dowels.

In the end, the shotcrete procedures were not only successful, but much less expensive than the original design that called for cast-in-place concrete, using form and pour methods. Shotcrete provided such a significant cost savings that the owner was able to increase the scope of the project to include shotcreting of the right wall, which was originally omitted from the scope of work. In addition to the monetary savings, the shotcrete was constructed much more quickly than formed, cast-in-place concrete construction could have been. It is highly unlikely that the expanded scope of work could have been completed in two construction seasons using conventional construction methods. On this project, as on many other projects, the time savings by using the shotcrete process can be even more important than just the construction cost savings.

After completion of the project, the owner conducted extensive studies of the shotcrete works and concluded that shotcrete was very acceptable as an alternative on this particular project. The owner was very happy with the installation and has stated that they will specify shotcrete for structural applications of a similar nature in the future.


## Acknowledgments

### Owner:

United States Department of the Interior Bureau of Reclamation
Pacific Northwest Division
Yakima Construction Office

**Contacts:**

Bernie Meskimen, Project Construction Engineer
Bill Brooks, Construction Engineer
John Billingsly, Project Engineer
P. O. Box 2967
Yakima, WA 98907-2967
Phone: 509-575-5946

### General Contractor:

Johnson Western Gunite Company
940 Doolittle Drive
San Leandro, CA 94577
Phone: 510-568-8112
Fax: 510-568-1601
E-mail: larry_totten@jwgunite.com

**Project Manager:**

Larry Totten

**Superintendents:**

Fred Harvey, General Superintendent
Lawrence (Doug) Douglass, Shotcrete Superintendent

### Consultant:

Agra Earth & Environmental (now AMEC)
2227 Douglas Road
Burnaby, British Columbia
Canada, V5C 5A9

**Project Manager:**

D. R. (Rusty) Morgan
Neil McAskill, Shotcrete Nozzleman Certification


*Larry Totten is the current President of Johnson Western Gunite Company. He has also served as a project manager and chief estimator in his 26 years with the company. He has an MS and BS in civil engineering, is a member of the American Shotcrete Association (ASA), ASCE, ACI, and AGC. He holds contractors licenses in six states and is a P.E. in California. He is the chairman of the Laborers Craft Committee of the Associated General Contractors of California. His industry leadership includes membership in ACI Committee 506, Shotcreting; Chairman of the Northern California Laborers Trust Fund; Directorship of ASA; and is an Approved ASA Trainer for the ACI Shotcrete Nozzleman Certification Program.*