2018 Outstanding Infrastructure Project

Oroville Dam Emergency Recovery

By Mick Haggerty

Oroville Dam, built in 1957, is an earth-filled embankment dam located on the Feather River, east of the city of Oroville, CA, in the Sierra Nevada foothills east of the Sacramento Valley. At 779 ft (238 m) high, Oroville Dam is the tallest dam in the United States, 20 ft (7 m) taller than the Hoover Dam. The dam serves mainly for water supply, hydroelectricity generation, and flood control.

BACKGROUND

In February 2017, after an emergency discharge due to extensive rain events, Oroville Dam's main spillway chute and emergency spillway were damaged, prompting the evacuation of more than 180,000 people living downstream. The State of California, Department of Water Resources, enacted an emergency repair project shortly after the event.

The $1.1 billion emergency repair of the Oroville Dam Spillway spanned multiple wet seasons. The scale of the project is massive, including 1 million yd^3 (0.8 million m^3) of earth moved, 2.3 million yd^3 (1.8 million m^3) of aggregate crushed, and over 1.5 million yd^3 (1.15 m^3) of concrete placed—all completed in approximately 18 months.

REPAIR OF THE OROVILLE DAM

The repair job was divided into two phases because work on the main spillway is off-limits to construction during the winter, rainy season, from December until May. Phase 1 was predominately temporary structures to stabilize the dam spillways before another rainy season where the dam may be required to have water discharged. Phase 2 included removing portions of the temporary work and replacing them with permanent structures.

In Phase 1, roller-compacted concrete (RCC) was used to fill in the portions of the spillway that were washed out. A 1100 ft long, 200 ft deep (335 x 60 m) trench in the main spillway had been undercut and significantly damaged during the February 2017 emergency discharge. When it became clear that the volume of the repair would push the completion date beyond the Phase 1 deadline for the next rainy season and potential water discharge, shotcrete was chosen to accelerate the temporary spillway walls. With an aggressive schedule of extended, staggered shifts and weekend work, the spillway was completed in approximately 4 weeks.

The middle third portion of the 3000 ft (900 m) long spillway used 6 in. (150 mm) thick shotcrete for the spillway walls against the RCC berms on either side of the spillway. The 2500 ft (760 m) of walls were reinforced with welded wire mesh and epoxy anchors back into the RCC berm. The concrete mixture, furnished by Mathews Readymix, LLC, included 752 lb (341 kg) of cement and 3/8 in. (10 mm) pea gravel, with hot weather concrete provisions for ice and a set retarder. Slumps were 1 to 3 in. (25 to 75 mm). The walls were given a smooth trowel finish. Properly prepared construction joints were provided between placements.

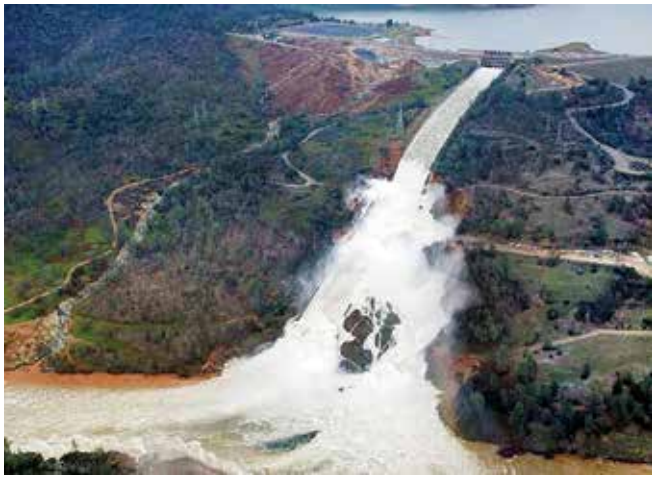

Fig. 1: February 2017 Oroville Dam main spillway is damaged

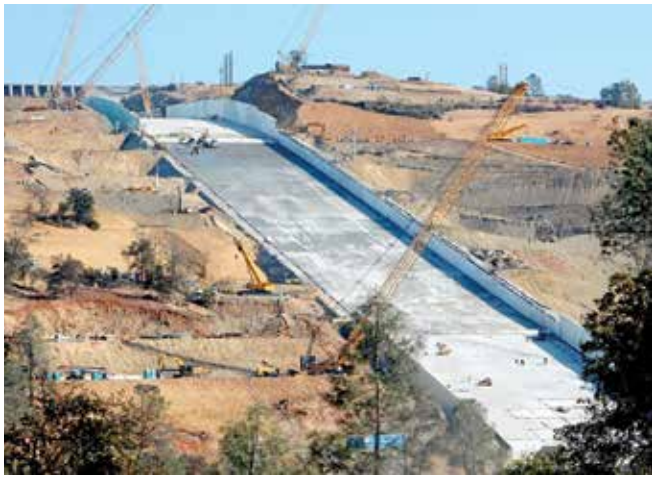

Fig. 2: Middle third of the 3000 ft (900 m) main spillway chute

Fig. 3: RCC berm supporting main spillway walls

Fig. 5: Shotcrete substrate of RCC berm and WWF reinforcing

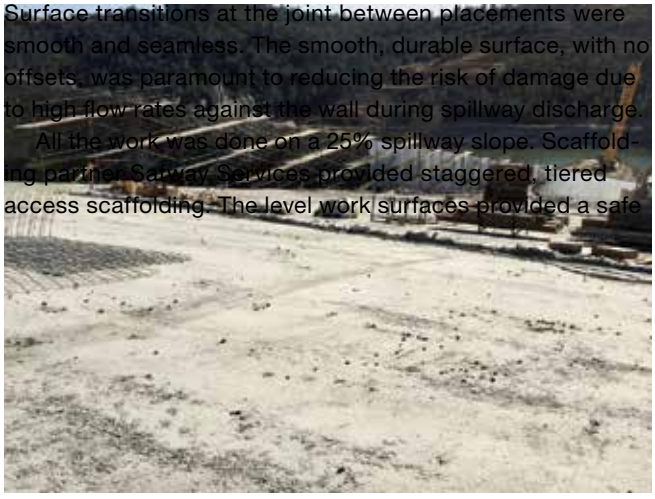

Fig. 4: Staggered and tiered work platforms on 25% slope

Fig. 6: Deep trench in middle third of main spillway chute, temporary shotcrete walls

Surface transitions at the joint between placements were smooth and seamless. The smooth, durable surface, with no offsets, was paramount to reducing the risk of damage due to high flow rates against the wall during spillway discharge.

All the work was done on a 25% spillway slope. Scaffolding partner Safway Services provided staggered, tiered access scaffolding. The level work surfaces provided a safe and productive work platform to allow our shotcrete crews to produce the exceptionally smooth and durable concrete surface and meet the emergency repair schedule deadlines. Superior Gunite achieved a record of zero recordable incidents in this remote location exposed to high heat, heights, incline hazards, and movement of heavy equipment. An excellent result by our experienced crews with exceptional safety leadership provided on the project by the General Contractor, Kiewit Infrastructure West.

CONCLUSIONS

The decision to build the spillway walls with shotcrete saved time and money as compared to form-and-pour methods, ensuring the spillway was available for use in time for the rainy season. Using shotcrete allowed the dam to be repaired and strengthened to safely allow the dam to have water discharges during the rainy season.

Fig. 7: View looking down spillway chute at temporary shotcrete walls

2018 OUTSTANDING INFRASTRUCTURE PROJECT

Project Name
Oroville Dam Emergency Recovery Project

Project Location
Oroville, CA

Shotcrete Contractor
Superior Gunite*

Architect/Engineer
State of California, Department of Water Resources

Material Supplier/Manufacturer
Mathews Readymix, LLC

Equipment Manufacturer
Western Shotcrete Equipment*

General Contractor
Kiewit Infrastructure West Co.

Project Owner
State of California, Department of Water Resources

Trade Partner
Safway Services

*Corporate Member of the American Shotcrete Association

Acknowledgments

A special thank you to State of California, Department of Water Resources; all of Kiewit Infrastructure West support staff; and trade partners, Mathews Readymix and Safway Scaffold. Superior Gunite achieves or exceeds its customer's goals on the most difficult, schedule-driven projects, only through the efforts and pride of its co-workers.

Mick Haggerty *is Superior Gunite's Vice President of Operations for the Western U.S. He received his BS in civil engineering from Washington State University, Pullman, WA, and his MBA from Seattle University, Seattle, WA. Haggerty has over 30 years of experience in concrete construction, both as a subcontractor and prime contractor. He is an active member of the American Shotcrete Association, American Concrete Institute, American Society of Concrete Contractors, and the Associated General Contractors of America.*