

# Shotcrete Meets the Challenge of Huge Water Project in Ecuador

by Mary Jane Loevlie and Kristian Loevlie

**B**y replacing traditional “form-and-pour” reinforced concrete construction methods with high-production shotcrete, the massive Traslvases Manabi Water Project in Ecuador was finished months ahead of schedule. Contractor Norberto Odebrecht, in conjunction with Shotcrete Technologies, Inc., of Idaho Springs, Colorado; and Commercial Shotcrete, Inc., of Higley, Arizona, placed over 6000 m<sup>3</sup> (7800 yd<sup>3</sup>) of shotcrete in less than half the time it would have taken by the specified “form-and-pour” method. They put the project an entire rainy season (approximately four months) ahead of schedule.

The Traslvases Manabi Water Project’s goal is to optimize Ecuador’s seasonal rainfall patterns by linking a trio of reservoirs and constructing pipelines and transfer and delivery tunnels to control water distribution. The end result is a constant supply of water for drinking, irrigation, and industrial use. General Contractor Norberto Odebrecht was hired by the Centro de Rehabilitacion of Manabi (CRM), the government agency responsible for water improvements. Odebrecht owns the largest contracting firm in Brazil, with more than 42,000 employees on the payroll.

Arriving on site in May 1999, Odebrecht’s responsibility was to increase the water supply to Portoviejo, the principal city in the province, and the surrounding regions. His plan was to construct a pumping station to lift water from La Esperanza Reservoir into a pipeline that feeds into an 11.4-km long (7.1 mi) tunnel, which would discharge into the Poza Honda Reservoir and the Mancha Grande River.

By July 2001, the project was five months ahead of schedule. Danilo Abdanur, the construction manager for Odebrecht, began to realize that they could possibly complete the entire project by the rainy season (late November). The logistical challenge to maintain the “ahead-of-schedule pace” on this \$140-million-dollar project called for some creative solutions.

To complete the project by the end of November 2001, the major challenge was to erect the reinforced concrete spillway walls of the Conguillo dam portion of the project. At 25 m (82 ft) high, with 600- and 1000-mm-thick (24 and 40 in.) walls, and with a 1% tolerance and a minimum of 6000 m<sup>3</sup> (7800 yd<sup>3</sup>) to place, traditional form-and-pour would not meet Abdanur’s aggressive schedule.

Kristian Loevlie of Shotcrete Technologies, Inc., was called in by Odebrecht and the owners to meet with them and the engineers to discuss the possibility of erecting these massive walls using shotcrete. The experience of Shotcrete Technologies with high-volume shotcrete all over the world, and information confirming that good shotcrete is indeed high-quality “in-place” concrete, often with much higher compressive strength, convinced the group that this was the answer to their dilemma and a unanimous decision was made to go full speed in shotcreting the entire 6000 m<sup>3</sup> (7800 yd<sup>3</sup>).

Time was of the essence, and Shotcrete Technologies quickly pulled all the logistics together, including: application experts; various mixture designs; a local supply of materials— sand, aggregate, and plasticizer; and then trained local laborers to execute the shotcrete application and finish. A local naphthalene-based superplasticizer was used and an alkali-free accelerator manufactured by Shotcrete Technologies was used for water control and temporary ground support. Commercial Shotcrete, Inc., was chosen to partner with



*Note the heavy rebar cages on the left, which are prepared to receive shotcrete.*

Shotcrete Technologies and Odebrecht to supply equipment, as well as expertise and supervision in training and working with the shotcrete crews.

Developing a good, consistent shotcrete mixture for this scope of work was vital to the success of the job. Odebrecht had its own batch plant on site, making it relatively simple to test all of the mixture components. After trying various sands, aggregates, and cements—using as many local materials as possible—the team came up with a workable/pumpable shotcrete mixture design, which included:

Cement—430 kg/m<sup>3</sup> (725 lb/yd<sup>3</sup>);

w/c—0.45;

10-mm aggregate—440 kg/m<sup>3</sup> (740 lb/yd<sup>3</sup>);

Sand—1130 kg/m<sup>3</sup> (1905 lb/yd<sup>3</sup>); and

Superplasticizer—13 kg/m<sup>3</sup> (21 lb/yd<sup>3</sup>).

The mixture's design strength was 24 MPa (3480 psi) at 28 days, and in-place testing produced an average strength of 32 MPa (4640 psi).

Once Commercial Shotcrete's pumps arrived, the first two weeks were focused primarily on training the locals in shotcrete technique. Alberto Medina, General Manager, and various supervisors from Commercial Shotcrete, oversaw the entire application process, from training the crews to nozzling and pumping, setting up guide wires, and finishing. As soon as the training was accomplished, crews reached a daily production rate of more than 180 m<sup>3</sup> (235 yd<sup>3</sup>) of shotcrete using two pumps on two shifts.

The shotcrete was placed through heavy rebar and mesh (as specified) directly onto a 25-m-high (82 ft) dirt excavation requiring extensive temporary support. By using shotcrete, the initial support and the final 1-m-thick (40 in.) structural walls were constructed simultaneously. This continuous process of excavation, reinforcement, initial support, and construction of the final structure was very fast, efficient, and cost-effective. It shaved months off the time traditional "form-and-pour" concrete methods would have taken. By the end of November 2001, the spillway walls were finished and ready for the rainy season.

According to Danilo Abdanur, Construction Manager for Odebrecht, the key to the project's success was choosing the proper equipment; setting up an efficient working site; mobilizing adequate support equipment; having a knowledgeable crew; having a workable and consistent shotcrete mixture design; and adhering to a daily maintenance routine. Abdanur's main concern, however, was taking a risk on technology that he had not previously used for this specific type of application. In addition to this unique shotcreting solution, Odebrecht also claimed a record for TBM advance following the breakthrough of the project's 4.6-km (2.9 mi) Transbasin Tunnel.

The Trasvases Project is one of the many innovative projects around the world for which Shotcrete Technologies, Inc., is known. This innovative solution shows the versatility and cost savings using shotcrete versus form-and-pour in many applications.

For further information, contact Shotcrete Technologies at [www.shotcretetechnologies.com](http://www.shotcretetechnologies.com) or Commercial Shotcrete, Inc., at [www.commercialshotcrete.com](http://www.commercialshotcrete.com).



View through the spillway of the Conguillo Dam, showing shotcrete directly onto the excavation.



Hand-held nozzling. As height was needed, the nozzleman was raised in a "bucket".

*Aerial photo of a portion of the Traslvases Manabai project with the Conguillo Dam in the foreground.*



*Mary Jane Loevlie is Vice President of Shotcrete Technologies, and she also co-founded the company in 1979. She has worked in or around mining, construction, and all types of shotcrete projects since 1979. She has written and published articles in several technical publications on various topics relating to shotcrete construction practices.*

*Kristian Loevlie is the President of Shotcrete Technologies and has been in the shotcrete business in Norway since 1973. He has worked on shotcrete projects—both surface and underground—all over the world. He has developed admixtures, nozzles, robotic arms, and many other innovations to promote the safe and efficient use of shotcrete. He is a member of ACI Committee 506, Shotcreting, and serves on many subcommittees. He is a member of the Underground Technology Research Council (UTRC). He is also a member of the Transportation Research Board's committee on Tunnels and Underground Structures, A2C04. He is a founding member and past Director of ASA.*