Flood Control Channels Made with Shotcrete

By Raúl Bracamontes

Flooding is a temporary overflow of water onto land that is normally dry. Floods are the most common natural disaster in the United States. This year, we have seen severe flooding in the Midwest that has cost countless millions of dollars in damage to property or restriction of use of our waterways. Floods may:

- Result from rain, snow, coastal storms, storm surges, and overflows of dams and other water systems;
- Develop slowly or quickly and can occur with no warning;
- Cause outages, disrupt transportation, damage buildings, and create landslides; and
- In the worst case, kill people.

Fig. 1: Casting the arched culvert floor

FLOOD CONTROL CHANNELS

Flood control structures such as arch culverts and concrete-lined channels are built to control the flow of water from flooding events to prevent or minimize damage to structures and infrastructure. Flood control channels are large, open-topped canals that direct the excessive water flow during flood conditions. They commonly are empty or have a minimal flow of water in normal service. In large metropolitan areas, we have seen underground tunnels or conduits to collect the excess water and eventually drain into a stormwater containment structure, river, or other body of water. There is a distinct trend away from letting stormwater just run into our oceans, rivers, or wetlands as it is often loaded with contaminants that reduce water quality. These structures are usually built with reinforced concrete. They may also contain grade-control sills or weirs to prevent erosion and maintain a level water level in the streambed.

BENEFITS OF SHOTCRETE

Shotcrete is becoming more popular among contractors and builders as it is extremely economical and flexible. Shotcrete placement produces a finished product that exhibits superior hardened properties when compared to form-and-pour applications and allows a wide variety of surface finishes. Some of the inherent benefits of shotcrete include high strength, low permeability, and thus increased durability.

Fig. 2: Forms ready to receive reinforcing steel

Fig. 3: Reinforcing steel in place over the supporting arch form

Fig. 4: Shotcrete placement starting at the bottom of the arched wall

Fig. 5: Shotcrete placement further up the arched wall

Prime application areas for shotcrete in water-retaining structures include sea and river walls, aqueducts, reservoirs, tanks, dams, canal linings, and irrigation and drainage channels. Using shotcrete for construction of arched culverts has also become popular. The shotcrete process provides several advantages in comparison with form-and-pour construction of these arched culverts, such as reducing construction time, form material and costs; lowering material handling; and producing excellent bond with most substrates, particularly on complex forms or shapes.

CONSTRUCTION PROCESS OF THE LEBARON CHANNEL

The Lebaron channel in Nevada described herein was constructed by Hydro-Arch, a shotcrete contractor focused on the concrete arched culvert business. The construction process for the arched culvert began with the excavation of the subgrade soils to the desired level, placement of the subbase material and reinforcing steel, and casting of the concrete slab that forms the floor of the culvert. Once the concrete floor gains enough strength, the prefabricated arch forms are placed and bolted together to create a continuous form. Sometimes, a custom wood form is fabricated to fit the radius of the tunnel. The steel reinforcing is then placed on top of the culvert form. Now, the forms are ready to receive the shotcrete placement of concrete on top of the arched form.

Fig. 6: Cleaning and roughening the construction joint before shotcrete placement starts on the top of the arch

Shotcrete placement starts at the bottom of the walls and then moves to the top to complete the arch section. The joint between placements is always properly prepared to facilitate the bond and water tightness for the next placement. Construction joints must always be roughened, cleaned, and brought to saturated surface-dry (SSD) condition before the subsequent placement commences.

A 3 in. (75 mm) slump and 4500 psi (31 MPa) concrete mixture design was used for the wet-mix shotcrete placement. Proper placement of shotcrete is critical to achieve high-quality, durable concrete. The thickness of the shotcrete ranges from 6 to 18 in. (150 to 450 mm), depending on the section and dimension of the arch. Quality shotcrete placement requires full compaction of the concrete, with forms and reinforcement free of overspray and rebound, and proper encasement of reinforcement.

The shotcrete nozzleman is the crew member most directly responsible for placing quality shotcrete. Use of

Fig. 7: Shooting the top section of the arch

Fig. 8: An overview of shooting the top of the arched culvert

an ACI-certified shotcrete nozzleman can help ensure that this critical member of the field crew has the knowledge and experience to place high-quality shotcrete.

Once the shotcrete is placed, a fresno trowel finish is provided. Immediately after finishing, the surface is coated with a spray-on curing membrane to help the concrete reach its desired strength, reduce cracking potential, and provide

Fig. 9: A fresno trowel finish is provided on the shotcrete surface

lower permeability. A liquid waterproofing membrane is often applied after the concrete has reached the desired age and surface moisture content.

CONCLUSIONS

Shotcrete placement for construction of these arched culverts provides faster construction, simplified formwork requirements, and allows ease of creating any curves desired. Overall, this means shotcrete saves the owner money while providing superior concrete that has higher strength, lower permeability, and will provide better long-term durability than conventional form-and-pour solutions.

***Raúl Armando Bracamontes Jiménez**, Ing., graduated from ITESO University (Instituto de Estudios Superiores de Occidente) in 1994 with a degree in civil engineering and has been working in the concrete industry ever since. Currently the owner of ADRA Ingeniería S.A. de C.V. since 2005, he is fluent in Spanish and English with multiple publications and courses given on shotcrete on his résumé. He is an ACI Certified Wet-Mix Nozzleman and Approved Examiner. Bracamontes is a member of Instituto Mexicano del Cemento y del Concreto (IMCYC), Colegio de Ingenieros Civiles de León (CICL), and the American Shotcrete Association.*

Fig. 10: A membrane curing compound being sprayed on the fresh shotcrete surface

Fig. 11: Backfilling of the culvert

Fig. 12: An interior view of the finished culvert