Hickory Log Creek RCC Dam and Reservoir Will Supply Much Needed Water

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The Cobb County-Marietta Water Authority (CCMWA) and the City of Canton , Ga., recognized the need and started the planning process for a new water supply reservoir more than ten years ago. The resulting roller-compacted concrete (RCC) dam to create the reservoir is being completed at the same time the area is experiencing the worst drought on record.

Hickory Log Creek Dam is a 180-ft (55-m) high, 956-ft (291-m) long RCC gravity dam. The dam will impound a 411-acre (166-hectare) reservoir with a supply capacity of 44 mgd (167 mld). A pump station located approximately 1.5 miles (2.4 km) below the dam on the Etowah River will provide water for initial filling and will supplement the reservoir to maintain the desired supply capacity.

Completed Hickory Log Creek RCC Dam.

Early planning studies identified that both an earthen dam and an RCC dam were potential viable options for the site. Because the type of dam would not affect the yield, the selection was based on economics and schedule. After considering all the various factors, it was determined that the RCC dam would cost about $4 million less and can be completed within the City's ambitious schedule to complete construction by end of October 2007.

Planning and Design Parameters

Since the accelerated project schedule would not allow for completion of the entire design and approval by Georgia Safe Dams Program prior to start of construction, the project was separated into two phases. Phase I design and construction work covered foundation excavation and treatment, infrastructure improvements, and erosion and sediment controls. Additionally, Phase I foundation work served as an extension of the geotechnical/geological field exploration program. To overcome the fact that portions of the dam's footprint area were inaccessible due to steep rock slopes, the team decided to continue the subsurface investigation work after the foundation was exposed and access was more affordable. Phase II work covered building the RCC dam and reinforced concrete training walls and ogee crest spillway. This phase design work progressed while Phase I construction was underway.

The project design storm was the probable maximum precipitation (PMP), which over the 8.2 square mile (21.2 km^2) drainage basin produced an inflow of nearly 64,000 cfs (181 m^3/sec.) during a hypothetical 6-hour storm. Due to property constraints, only 10 ft (3 m) was available above the normal pool to top-of-dam. To pass the design storm safely through the spillway with a maximum head of 10 ft (3 m), a 250-ft (76-m) long spillway with ogee crest was designed. A 110-ft (33.5-m) long gated spillway section was designed in the center of the spillway width that included a 6-ft (1.8-m) high Obermeyer Crest Gate. When the crest gate is fully lowered, this spillway section has the capacity to pass 16 ft (4.9 m) of reservoir head.

Because the dam site contained a very narrow valley with steep abutments, a 250-ft (76-m) long spillway crest transitioning to a 130-ft (39.6-m) wide stilling basin was designed. Design calculations and a hydraulic model study performed at the Utah Water Research Laboratory at Utah State University in Logan, confirmed that this configuration would safely pass the design storm.

Construction

The low-bid for the first phase contract was $5.1 million and was awarded to Thalle Construction Company in October 2005. The Phase I Contract consisted of the foundation excavation, abutment preparation, temporary stream diversion, site access roads and the primary staging area, and concrete cutoff wall construction and grouting program. The contractor completed the mass excavation by late February 2006 and began selective blasting of the rock foundation in early March. Blasting operations were completed by July.

Nicholson Construction Company, as a subcontractor to Thalle Construction Company, performed the grouting program between late June and mid-October 2006. This consisted of a double row grout curtain with primary holes located at 20 ft (6.1 m) on centers. The depth of the grout curtain was generally 25 ft (7.6 m) in the floodplain area and 35 to 80 ft (10.7 to 24.4 m) within the abutment areas. A drainage/inspection gallery was designed within the dam with the center of the gallery located 18 ft (5.5 m) downstream of the dam baseline (front face of the dam) and extending up the majority of the abutment face.

The very ends of the abutment sections were founded on partially weathered rock (PWR) containing numerous seams of fine-grained material that would limit the installation of a grout curtain in this area. A 20-ft (6.1-m) deep concrete cutoff wall was constructed through the PWR at each abutment end.

At $36.6 million, Thalle was also the low bidder on the second phase of the project. Subsequently, Thalle teamed with ASI Constructors, Inc. as a subcontractor to construct the dam.

The main section of the dam was built using RCC. Geomembrane-lined panels, anchored to the vertical upstream face achieved the dam's waterproofing. Capri provided the liner The downstream face of the dam was constructed with conventional concrete within the spillway area and grout enriched RCC elsewhere. The slope of the downstream face is 0.8H:1V.

The conventional concrete steps within the spillway section were built concurrently with the dam RCC lifts. However, the spillway training walls were constructed afterwards using self-consolidated concrete. The stilling basin portion of the spillway was built with reinforced conventional concrete and rock anchors anchored the stilling basin to the underlaying bedrock.

The drainage and monitoring gallery of the dam has exposed RCC walls with a conventional concrete floor and prefabricated steel reinforced concrete roof lids. Foundation drains, piezometers, and inclinometers were drilled and installed during the gallery construction. The gallery spans approximately two-thirds the length of the dam.

RCC Mixing and Placement

RCC was produced using a portable C.S. Johnson-Ross Bandit BTRR-600 batch type plant and an IHI HyDam 4500D mixer. Although the plant capacity is 800 tons per hour, it normally operated at a production rate of 550 tons per hour.

RCC was delivered from the batch plant to the dam via a nearly 2,500-ft (762-m) long ROTEC conveyor belt. A ROTEC tripper and a 60-ft (18.3-m) long swinging conveyor delivered RCC to different locations of the dam. The swinging conveyor had an elephant trunk at the end to reduce segregation at the point of discharge.

RCC plant and aggregate stockpiles.

General view of RCC conveying system and placement.

Upstream facing details.

Three different-size dozers spread the RCC in 12-inch (300-mm) lifts. The dozers were equipped with laser-guided systems to obtain a level surface. Where space was limited or access was difficult, a small Komatsu D-21 was used. Elsewhere, spreading was accomplished with a larger size John-Deere 850J dozer and a mid size Caterpillar D5. The D5 was also used to finish grade the RCC lifts.

Horizontal surfaces exposed for more than 500 degree-hours were considered cold joints and required spreading an approximately 3/8-inch (10-mm) thick bedding mortar layer just prior to placement of new RCC lift. The bedding mix contained 800 lbs of cement with a water cement ratio of 0.59. Cold joints older than 36 hours required pressure washing before spreading the bedding mortar.

The project specifications required the RCC to be compacted to a minimum density of 97 percent of Theoretical Air-Free Density. A double drum Ingersoll-Rand DD-130 and a single-drum Ingersoll-Rand SD-100 were used to compact the RCC. Generally four passes with the double-drum roller were sufficient to achieve the required density. A higher number of passes was needed when using the single-drum roller. The areas adjacent to the upstream and downstream faces of the dam were compacted using a smaller Ingersoll-Rand DD-24. Sections where access was difficult were compacted using plate tampers and jumping jacks.

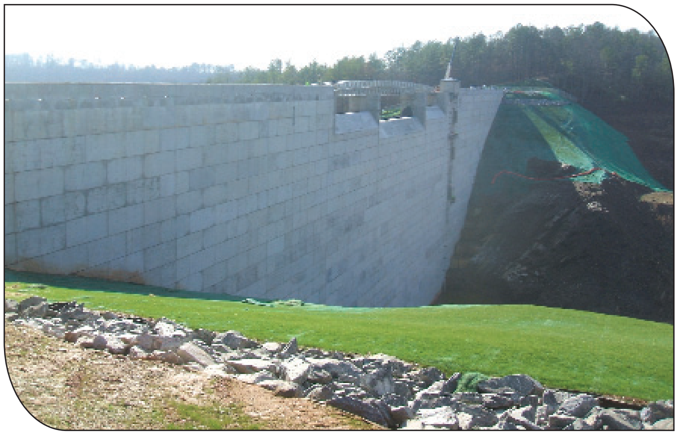
The RCC placement started in mid-December 2006 and was completed in early June 2007. The placement was performed with one shift up to the top of the gallery and then two shifts for most of the reminder of the dam. Typically, the afternoon hours were used to set panels and forms.

Facing Systems and Temporary Formwork

A total of 2000 full size [6 ft x 16.5 ft (1.8 m x 5.0 m)] as well as 500 half-size precast concrete panels were fabricated on site. All panels were 5-inch (125 mm) thick and served as formwork for RCC placement. Those installed on the upstream face were lined with a flexible CARPI 40 mil synthetic waterproofing membrane). The panels installed on the downstream side of the chimney section have a decorative face for aesthetical purposes. Wood forms were used to form the steps of the downstream side of the dam.

Training wall and steps showing conventional concrete on right and grout-enriched RCC on left.

Grout-enriched RCC was used to give the exposed downstream steps of the dam an improved appearance compared to typical exposed RCC. A grout mix was prepared using a colloidal mixing plant at the proportions of one part of portland cement to one part of water by weight. After the RCC had been graded and prior to compaction, the grout was manually poured over the top of the freshly placed RCC adjacent to the downstream wood forms. Workers would then internally vibrate the grout into the fresh RCC. Compaction of the RCC in this area was done using flat bottom plate tampers, resulting in a smooth, aesthetically pleasing exposed step.



General view of upstream face of completed dam prior to initial filling.

RCC QUALITY CONTROL

RCC Aggregates

Aggregate for RCC was crushed from Lafarge North America's Ballground, Ga., quarry. Graded aggregate base and No. 4 coarse aggregate were transported to the site and stored in two separate stockpiles near the RCC mixing plant. Aggregate gradation was performed at three different points: at the quarry prior to transporting, on samples obtained from the stockpiles, and on mixing plant belt samples to check the gradation of combined aggregates. The maximum aggregate size for the combined blend was 2 inches (50 mm). In most cases, gradations of the blended aggregates met the specified limits for the project.

RCC Mix

The RCC specified compressive strength was 2000 psi (14.8 MPa) at 180 days. A complete laboratory testing program was implemented to determine the fresh properties as well as the mechanical properties of hardened RRC using three different mix proportions. Testing methods included Vebe time, unit weight, air content and moisture content. Additionally, testing to evaluate mechanical RCC properties was done using 6 inch x 12 inch (150 mm x 300 mm) cylinders. Mechanical tests included compressive strength, indirect tensile strength and modulus of elasticity. Strength testing was also performed on accelerated curing specimens and correlations were developed to predict the 28 and 180 day strengths based on earlier strength test results. These correlations were used to forecast RCC strength during production testing. Companion strength specimens were cured normally and tested at ages up to 365 days.

Based on the specified strength and early test results, an RCC mix containing 150 lb/yd^3 (89 kg/m^3) Type I/II portland cement and 150 lb/yd^3 (89 kg/m^3) Class F fly ash was selected. After several weeks of RCC placement, the mix was adjusted and the following mix proportions were used for the remainder of the project: 135 lb/yd^3 (80 kg/m^3) Type I/II portland cement; 165 lb/yd^3 (98 kg/m^3) Class F fly ash; 3,600 lb/yd^3 (2,136 kg/m^3) crushed stone; and 225 lb/yd^3 (133 kg/m^3) water. The target Vebe time was 25 + 5 seconds.

Prior to the start of RCC placement within the dam footprint, an on-site test section was built to validate the contractor's means and methods and to check the performance of RCC mixes. The test section also provided an opportunity to train testing personnel.

Statistical analyses of production samples test results performed in accordance with the American Concrete Institute Committee Report 214, showed very good overall variation. The accelerated curing strength corresponding to 180-day strength for the project averaged 3,010 psi (20.8 MPa).

A total of 218,000 yd^3 (167,000 m^3) of RCC and 9,000 yd^3 (6,900 m^3) of conventional concrete were placed to build this 180-ft (55-m) high dam, which is the tallest non-federally regulated dam in Georgia. The in-place cost of RCC was \$74.67/yd^3 (\$97.66/m^3), including the cost of materials, mixing, transporting, placing and curing.

The project has been completed and initial filling is scheduled to commence in January 2008. Initial filling is expected to take 18 months to reach normal operating level. Creating this water supply reservoir will help fend off future water supply crisis for the rapidly growing City of Canton and for the wholesale customers of the water authority.

Credits

Owner: The City of Canton and The Cobb County-Marietta Water Authority, Georgia

Engineer: Schnabel Engineering, Alpharetta, GA

Contractors: Thalle Construction Company, Hillsborough, NC and ASI Constructors, Buena Vista, CO.

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