Elkwater Fork Dam– A Reliable Source of Drinking Water

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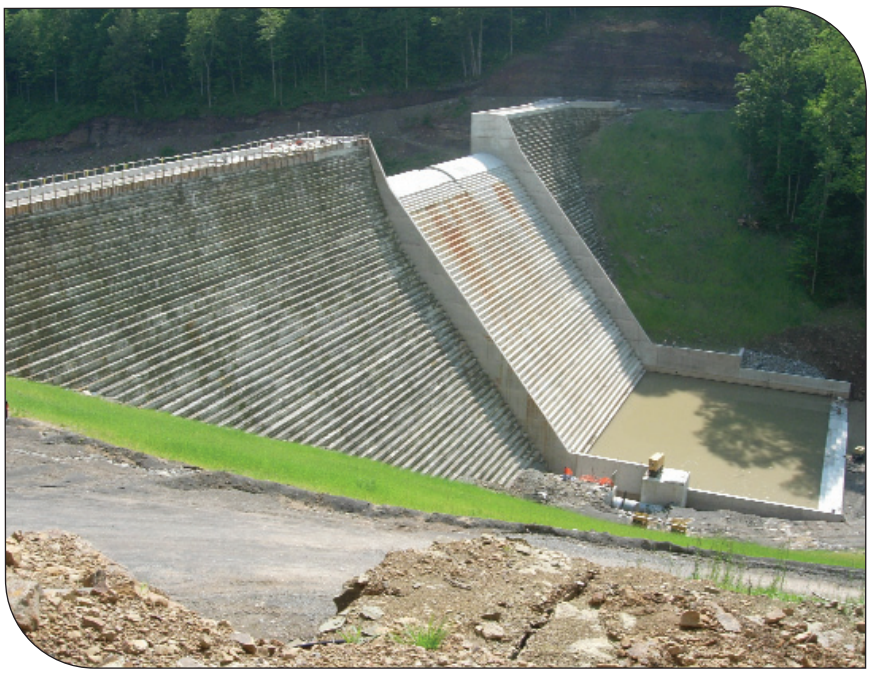
Elkwater Fork Dam is a new roller-compacted concrete gravity dam located in Randolph County, West Virginia. The Elkwater Fork Dam site was identified as part of a county-wide water resources study completed in the late 1990s by the Natural Resources Conservation Service in Morgantown, W.V. The purpose of the dam and reservoir is to provide a reliable source of drinking water to Elkins, W.V. and surrounding communities.

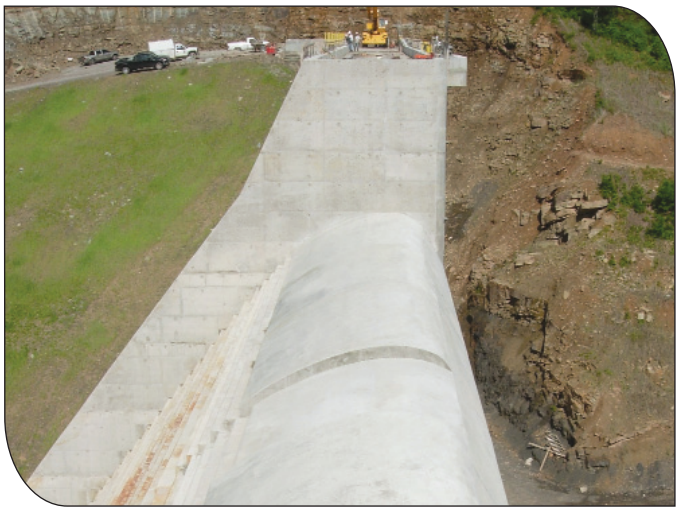


Elkwater Fork Dam almost complete as it appeared in June 2008

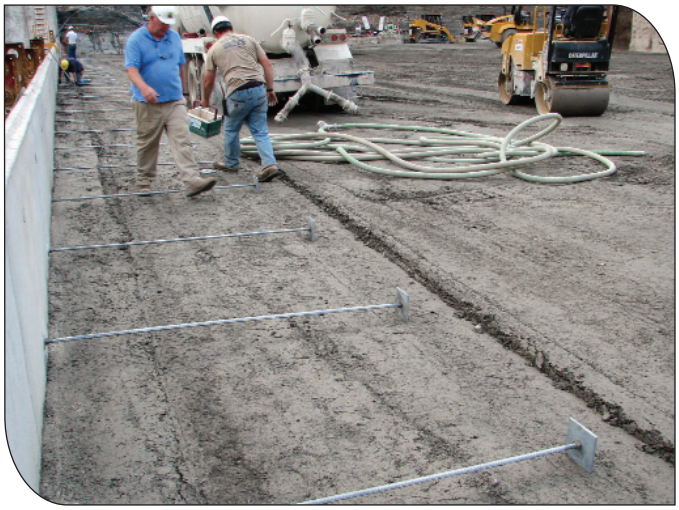
Project Description

The dam site is located on a tributary to the Tygart Valley River with a drainage area of approximately 8.4 square miles (21.8 km^2). The watershed, with the exception of some selective logging activity, is primarily undeveloped. The area is distinguished by its annual precipitation of approximately 60 inches (152 cm), making it an ideal location for a water supply reservoir.

The dam is 128-feet (39-m) high, measured to the streambed at its downstream toe, has a total length of 670 feet (204 m), and contains 139,000 cubic yards (106,300 m^3) of RCC. An uncontrolled overflow spillway is located in the central portion of the dam that will convey flood events up to and including the probable maximum flood. The upstream face of the dam is formed with 6-foot (1.8-m) high by 16-foot (4.9-m) long precast concrete panels with a PVC membrane bonded to the downstream face of the panels. Each panel is anchored with six, ¾-inch (19-mm) galvanized steel rods. The downstream face of the dam is formed with 2-foot (0.61-m) high steps. The steps are constructed with conventional concrete placed concurrently with the RCC within the spillway, and consist of formed RCC within the non-overflow sections of the dam. The top width of the dam is 18 feet (5.5 m).



Uncontrolled overflow spillway looking toward right abutment

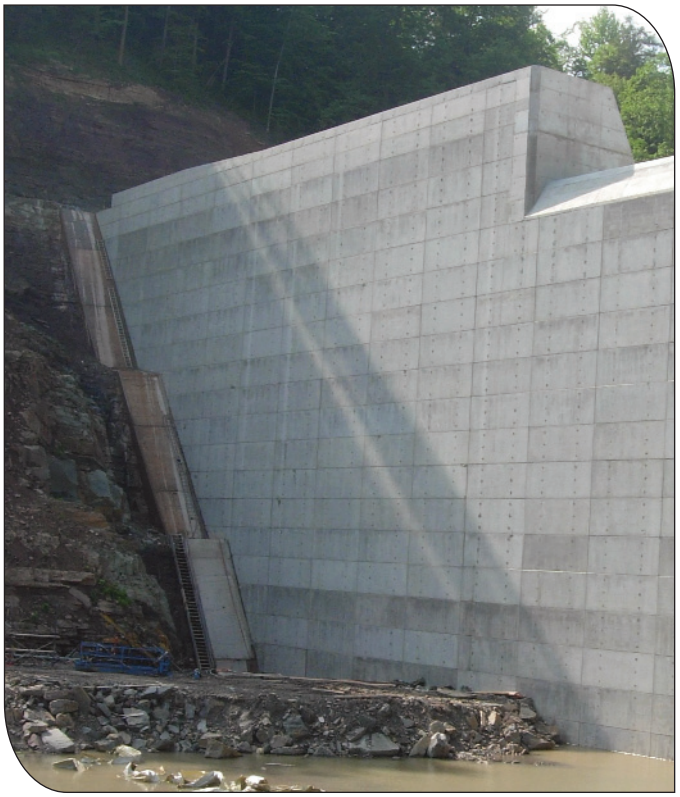


Precast concrete upstream facing with anchoring system

The outlet works facilities consist of a 72-inch (1.83-m) diameter low-level outlet, and a 30-inch (0.76-m) diameter water supply line. The water supply line can be fed by three inlets located on the upstream face of the dam. The low-level outlet also provided a means of stream diversion during construction.

A single-line grout curtain was constructed at the upstream heel of the dam. Holes were drilled from a concrete plinth after placement of RCC was complete. Grout holes vary in depth from 20 feet (6.1 m) to approximately 80 feet (24.4 m). Angled foundation drain holes were drilled from the downstream toe of the dam to relieve uplift pressure within the foundation.

Design of the project began in 2001 and construction was initiated in 2006. Placement of RCC was completed in 2007 and final completion of the project including installation of grout curtain is expected to be completed in September 2008. It is anticipated that reservoir filling will begin in the fall of 2008. Gannett Fleming, Inc. of Harrisburg, Pa. designed the dam. The prime construction contractor was Heeter Construction Company of Spencer, W.V. The project was managed by the Natural Resources Conservation Service in Morgantown.



A view of concrete plinth at the left abutment

Foundation Conditions

The depth to the dam foundation grade ranges from a few feet to nearly 60 feet (18 m) below the ground surface. The foundation cutoff key extends below this level. The deeper areas result from the high degree of weathering and fracturing observed at some locations and the need to remove this material to achieve a suitable dam foundation. The rock stratigraphy across the dam foundation is variable, consisting of alternating layers of

Table 1: RCC Mix Proportions

Component	Mix Weight lb/yd^3 (kg/m^3)		Specific Gravity	Absorption (%)
	Mix 1-Dam	Mix 2-Foundation Cutoff Key		
Coarse Aggregate	1926 (1143)	1896 (1125)	2.68	0.85
Fine Aggregate	1797 (1066)	1769 (1049)	2.69	1.95
Cement	100 (59.3)	125 (74.2)	3.15	--
Fly Ash	150 (89.0)	185 (109.7)	2.55	--
Water	174 (103.2)	174 (103.2)	1.00	--

sandstone and shale. The shale strata at the foundation level exhibited significant tendency to slake in the presence of air and moisture and was prone to deterioration. This characteristic resulted in the delay of foundation cleanup and preparation to just prior to concrete placement. The sandstone strata were much harder and quite resistant to weathering upon exposure.

Foundation grades were determined based on Rock Quality Designation (RQD), visual observation of core samples, and weathering and staining of natural rock fracture faces. While the foundation conditions were deemed to be suitable for the dam, there was some concern regarding sliding stability during extreme loading conditions. Therefore, a cutoff key at the heel of the dam was incorporated into the structure to provide additional base embedment in rock necessary to achieve adequate safety factors against sliding. The cutoff key has a maximum depth of approximately 30 feet (9.2 m).

RCC conveying system

RCC Mix Design

Based on structural analysis of the dam and assessment of the interaction between the dam and foundation, an RCC mix with a one-year compressive strength of 1,500 psi (10.3 MPa) was determined to satisfy the design criteria and equal or exceed computed stresses in the dam above the foundation cutoff key. A mix with a compressive strength of 2,500 psi (17.2 MPa) at one year satisfied the design criteria and equaled or exceeded computed stresses in the foundation cutoff key.

Mix proportions were computed in general accordance with the U. S. Army Corps of Engineers' Engineering Manual 1110-2-2006, *"Roller-Compacted Concrete."* The procedure was modified to permit utilization of a combined aggregate gradation successfully utilized on other similar projects. An air content of 1.5% was used in the trial mix proportioning for all mixes. Mixes were selected that would provide concrete properties for a range of cement contents, fly ash contents, and workability.

An aggregate blending analysis was performed to determine a preliminary blend of the two aggregate size groups based on comparison with target gradation bands used for prior RCC projects. The coarse aggregate consists of AASHTO No. 467 stone with a maximum size of 1.5 inches (37.5 mm). The fine aggregate is unwashed concrete sand with a maximum size of 3/8 inch (9.5 mm) and approximately 11 percent fines passing #200 sieve (75 μm). The initial aggregate blend utilized at the trial batching program was 55 percent coarse aggregate and 45 percent fine aggregate. Based on the preliminary blending analysis combined with observation of the batched mixes, a ratio of 52 percent coarse aggregate and 48 percent fine aggregate was selected for the mix.

All RCC was mixed with Type I/II portland cement and Class F fly ash supplied by Lafarge Corporation. Fine and coarse aggregates were supplied by Boxley Materials Company and J. F. Allen Company, respectively. Onsite well water was used for trial mix testing and production mixing of RCC.

Based on the testing described above, the mix proportions listed in Table 1 were recommended for use in the dam and foundation cutoff key.

Final mixes were proportioned for an air content of 2 percent. The aggregate weights are based on saturated

surface dry conditions. Water contents are "free mix water" above saturated surface-dry conditions. The actual mix water was adjusted during construction depending on placement conditions, RCC consistency (Vebe time) and aggregate water contents. In general, the water content was adjusted to achieve a target Vebe time of approximately 15 to 20 seconds at the point of placement, with an allowable range of 15 to 25 seconds.

RCC Construction

Because of the narrow valley at the location of the dam, there was very little available space for a staging area at the site. Fortunately, the valley widens out approximately 900 feet (274 m) downstream of the dam, providing a suitable staging area. Stockpiling of concrete aggregates within this area was initiated in the fall of 2006. In early 2007, setup of the concrete plant and conveyor system began. Gears, Inc. of Colorado Springs, Colorado supplied an AccuMix 750XB RCC mixing plant. The plant is a twin, horizontal shaft, continuous pug mill mixer with a peak capacity of 400 cubic yards per hour (306 m^3/hr.). RCC was conveyed from the concrete mixing plant to a transfer point just downstream of the dam via a 24-inch (0.61-m) wide conveyor belt supplied by Rotec Industries. From there, it was conveyed to the active lift surface with a Creter Crane, also supplied by Rotec. Once on the dam, the RCC was spread by a D5 dozer and compacted with 10-ton vibratory rollers. Placement occurred primarily during the night shift to meet the maximum placement temperature of 70˚ F (21˚C). Seven contraction joints were also incorporated in the dam to provide stress relief during post-placement cooling of the RCC and thereby reduce the potential for uncontrolled cracking of the concrete. The daily placement rate ranged from approximately 2,750 to 3,000 cubic yards (2,100 to 2,300 m^3). Foundation

General view looking at the upstream face of Elkwater Fork Dam

cleanup, setting of precast concrete panels and forms, and curing operations were performed during the warmer daytime hours. RCC placement was initiated in April 2007 and completed in August. The project required 139,000 cubic yards (106,300 m^3) of RCC and 8,500 cubic yards (6,500 m^3) of conventional concrete. The average in-place cost of RCC (cost of materials, mixing, transporting, placing and curing) was $79.12 per cubic yard ($103.48/m^3).

Credits

Owner: Tygarts Valley Conservation District

Project Manager: Natural Resources Conservation Service

Engineer: Gannett Fleming, Inc.

Contractor: Heeter Construction Company

RCC plant and plant operator: Gears, Inc.

PCA

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