Beneficial Use Case Study

Yusufeli Dam

Coal Combustion Product Type
Fly Ash

Project Name
Yusufeli Dam

Project Location
Artvin Province, Turkey

Project Participants
Limak Construction, ARQ Consulting Engineers, Su-Yapi Engineering and Consulting, General Directorate of State Hydraulic Works

Project Completion Date
2023

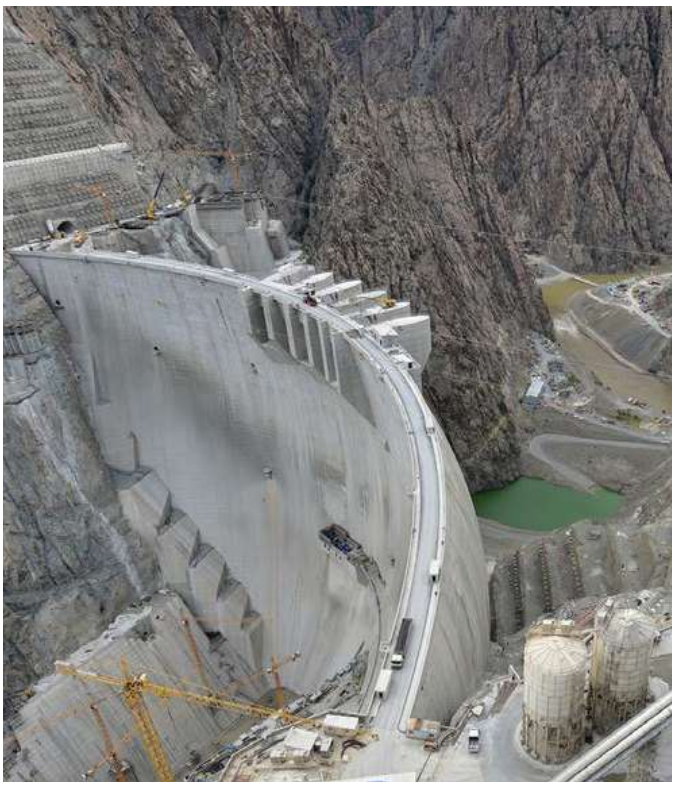
Project Summary
Yusufeli Dam is one of more than a dozen hydroelectric projects that are planned to be built in the Çoruh River District in northeastern Turkey. Part of the Turkish government's plan to replace imported gas and oil with domestic energy, the double-curvature concrete arch dam will store 2.2 billion cubic meters of water to power three 186-MW turbine units. After entering service at the end of 2023, it is now capable of producing 1,900 Gwh of electricity annually, or enough to meet the needs of 650,000 people.

Project Description
Situated in a steep and narrow gorge, Yusufeli Dam rises 275 meters from its foundation, making it the tallest dam in Turkey and the fifth-highest double-curvature arch dam in the world. With a crest length of 540 meters, a width at its base of 110 meters and at its top of 8 meters, the dam would eventually incorporate approximately 4 million cubic meters of concrete, presenting daunting thermal control challenges.

The dam was constructed as 29 individual cantilevered formwork-enclosed concrete blocks involving a total of 1,901 placement lifts each 3 meters in height. Blocks were then grouted together at the joints, but only after each concrete block had cooled to a pre-determined temperature to ensure the stability and air/water-tightness of the structure. Ensuring the structure's integrity while meeting the Turkish government's demands for a speedy construction schedule—initial plans called for placement of the concrete in a mere 26 months, meaning crews would have to place an average of approximately 150,000 cubic meters each month—required extensive thermal modeling and ongoing analysis during the dam's construction.

To help control the concrete's heat of hydration, engineers settled on a mix for the primary concrete (representing 80 percent of the dam concrete) containing 130 kg/m^3 CEM1 cement, 70 kg/m^3 fly ash, 110 liters/m^3 water, and 2,183 kg/m^3 aggregates with a maximum size of 120 mm—effectively a 35 percent fly ash substitution for cement. Cooling of the concrete post-placement was achieved using 19 mm-diameter steel cooling pipes in coils and required careful calibration to ensure that the concrete would not crack, while keeping the construction rate on the desired schedule. Use of fly ash is credited with helping keep the thermal stresses of the dam to a minimum during construction while allowing for the dam's completion in just 30 months.

After more than a decade of engineering and construction, followed by many months to fill the reservoir behind it, the dam is now running at full capacity.



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