International Milestone RCC Project

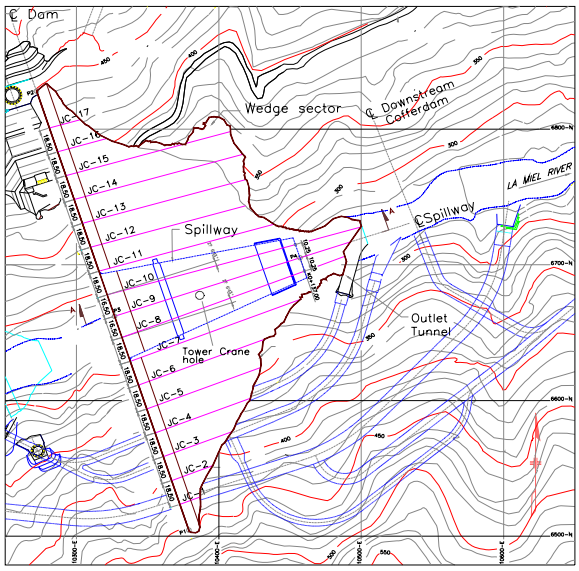
Miel I Dam

in Colombia

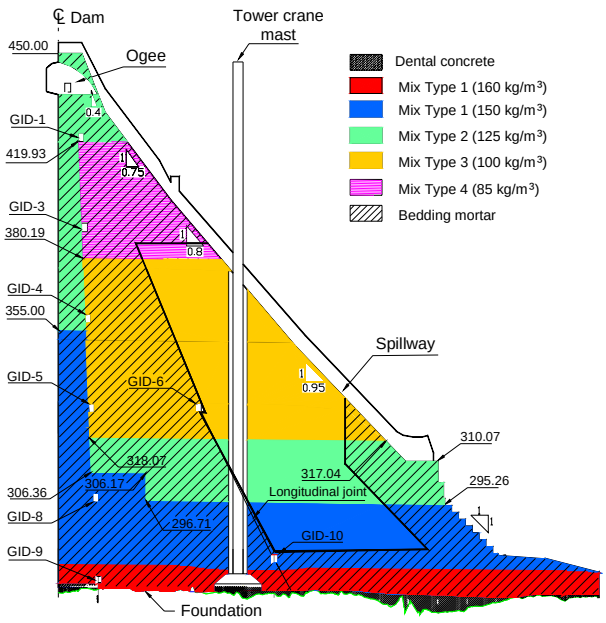
Installed capacity	375MW
Average annual generation	1460 GWh
Dam type	RCC gravity dam
Height of dam	188m
Length of crest	354.0m
Width of crest	8.0m
Downstream slope	Heel 1H:1V
	Crest 0.4H:1V
Total volume	1.7 million m^3
Construction period	2000-2002

The Miel I RCC dam, built in the years 2000-2002 in central Colombia, is a distinctive project in the world not only because of its record-breaking 188-m height by the time of construction, but also because of the harsh forest environment where it was built with high ambient temperature (up to 38°C) and significant rainfall (over 4200 mm/year). The dam is the main structure of the Miel I Hydroelectric Project, which also includes an underground power house with a capacity of 375 MW and an average annual generation of 1460 GWh.

The straight gravity dam has a height of 188 m (between elevations 266 m and 454 m). The width and length of the crest are 8,0 and 354,0 m, respectively. The downstream face is inclined and stepped, with a slope varying between 1H:1V at the heel and 0.4H:1V at the crest.



Dam Plan Layout



Dam Cross Section

As a result of the structural analyses, RCC five mixes of low to moderate cement content (85 to 160 kg/m^3) with no mineral admixtures were considered in the dam. No precooling of aggregates was necessary to achieve the specified placing temperatures of the RCC.

Due to shear strength requirements, bedding mix covered one half of the transversal length of the RCC layer. .Main design characteristics of the RCC dam include bedding mortar (10 mm thick) between lifts in most of the dam. RCC was placed in 0.3 m thick lifts.

Seventeen transversal contraction joints were provided for the dam, spaced every 18.5 m. By introducing this set of joints, the only requirements for concrete temperature control of a given mix were related to cement mixing temperature (60°C max.) and cement hydration heat (2800 cal/ gr max).

A single inclined longitudinal contraction joint was also provided in the design for the lower third part of the dam, parallel to the downstream face. The purpose of this joint was to provide a weakness plane within the RCC mass for an eventual induced crack and to prevent from thermal cracking spreading. If the joint opens, it can be grouted from the two galleries that intercept the joint plane allowing a significant degree of RCC continuity and therefore, a monolithic RCC behavior.

Imperviousness was achieved by a double system that consisted of a grout-enriched vibrated RCC zone (40 cm thick) and a PVC geo-membrane (3-4 mm tick) along the upstream face. The most significant benefit of GEV-RCC is to create a homogeneous barrier that prevents from leakage through the discontinuities within the RCC lifts and joints, rather than reducing the RCC mass permeability. The PVC membrane was anchored to the plinth and covers the upstream face of the dam. It was also anchored to galvanized steel shapes embedded into the GEV-RCC face. Any leakage collected behind the membrane is conveyed by a network of galvanized steel pipes to the drainage galleries inside the dam.

Contraction joints

PVC waterstops at contraction joints

Impervious face: GE-RCC production and placement

Bedding mix

Impervious face: Membrane

RCC placement was made by conveyor belts, a tower crane and a crawler placer, achieving monthly rates of up to 120,000 m^3. A total volume of 1.7 million cubic meters of RCC were placed in about 25 months.

The spillway, built at the central part of the downstream face of the dam, has a discharge capacity of 12,800 m^3/s (maximum discharge in 10,000 years). The upper opening of the spillway, located at elevation 445 m, has no gates and a width of 65 m. The spillway is enclosed by two converging 4-m-high walls and ends in a 32-m-wide ski jump. The total volume of conventional concrete needed to build the spillway is 17,200 cubic meters.

Instruments were installed within the dam body and the foundation to monitor RCC stress-strain behavior, temperature development, pore water pressures and joint displacements. These instruments consist of 334 thermocouples, 23 load cells, 45 strain gages, 117 contraction joint crackmeters, 10 longitudinal joint crackmeters and 82 piezometers, distributed in arrays at seven different levels of the dam. Instrument readings are being collected and analyzed during the project construction in a data center.

Results of instrument installed within the dam and its foundation to monitor the structural behavior confirm compliance with basic design assumptions. Leakage trough the dam body has been registered around 2 to 4 lts/sec and approximately 6 to 8 lts/ sec through the abutments. At the left abutment, a transversal joint showed an opening of about 5 mm that was treated with cement grout. Longitudinal joint does not show any movement. RCC was placed at temperatures ranging between 20 and 24°C and temperature developed within the RCC mass has been within the expected ranges.

Downstream of Miel I dam

Companies Involved in the Project

Owner: ISAGEN ENERGÍA PRODUCTIVA

Designer: *Hidroestudios*

Technical supervision: INGETEC S.A. INGENIEROS CONSULTORES

Contractor: *Joint Venture of Odebrecht, Kvaerner Energy and Alstom Power*