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Heritage

Chinda, Japan

Geological instability caused the historic Chinda Waterfall, Japan, to slowly move upstream during successive flood events, threatening dam safety. Careful attention to aesthetic detail was a feature of the project to stabilise the falls.

Overview

Situated in Ono-cho in the central part of Oita Prefecture, Japan, the Chinda Hydroelectric Power Plant is a run-of-river system with a maximum output of 8.3MW and a maximum usable discharge of 25.04m^3/s.

Dam Name

Scheme operator
Kyushu Electric Power Co Inc.

Size of scheme (MW)
8.3

Country
Japan

Catchment area

River
Ono

Effective reservoir capacity
Run of River

Construction years

Reservoir size
Run of River

External recognition
Nil

Details

Located on the mid sections of the Ono River, the Chinda Waterfall is renowned as a place of beauty, having been the subject of a famous Indian ink drawing respected

Japanese artist Sesshu (a Zen Buddhist Priest) some 500 years ago. Today, the Chinda Waterfall is a sightseeing destination that attracts both tourists and locals.

The waterfall is 28m in height, 110m in width and is comprised welded tuff with highly developed columnar and horizontal joints. Repeated landslips from heavy flood events had caused the waterfall to gradually recede, until the walls of the waterfall were immediately below the dam apron. Stabilisation of the falls became necessary in order to avert a dam break, however, the effort to stabilize the falls was dangerous, technically challenging and required sensitivity to the aesthetics of the site.

A computer generated conceptual drawing of the waterfall was prepared in consultation with river and landscape management experts and aided in determining the nature of the works. The collapse mode of the waterfall was toppling deformation originating in discontinuous surfaces, hence the Distinct Element Method (DEM) was the most appropriate tool for designing effective reinforcement work. This process showed that if the displacement and rotation of the lower part of the waterfall are restricted, downstream toppling deformation of the welded tuff under the dam apron would be suppressed, maintaining dam stability even during a 1 in 100 year flood event.

The stability of the rock face during periods of low water level in the basin and/or after removal of fallen blocks was analyzed in preparation for foot protection work. This indicated that the waterfall surface would become unstable if fallen blocks were removed. It was determined that rock bolts work would effectively restrict the separation collapse of columnar rock masses in the front row of the waterfall above the basin even in the event of an earthquake.

The works undertaken included the following:

- Permeable mats and drain pipes of 30mm in diameter were installed in 13 places to counter water confined to the gravel layer. Foot protection works commenced with the removal of rubble from fallen columnar blocks using heavy machinery. The sandstone surface was fully exposed at the end of this process.

- Discontinuous planes had developed on the face of the waterfall, and columnar rock blocks varied in size and shape. These planes were geometrically analyzed and their stability and surface irregularities examined using three-dimensional photographic techniques. Highly unstable blocks were stabilized using rock bolts into the walls of the waterfall.

- False rock work to disguised the structures used to stabilize the waterfall, resulting in a natural appearance in harmony with the surrounding environment.

Other aspects

Safety

These works resulted in the stabilization of a dam structure that would otherwise have been at risk of collapsing. The dangerous nature of the unstable waterfall face required the development of specialized equipment to provide workers with early warning of impending rock falls. This technology permitted completion of the project was completed without injury or loss of life.

Seismic

Rock bolts were used to stabilize the columnar rock mass in the front row of the waterfall in the event of an earthquake.

Further information

Source: Hydropower Good Practices Workshop, Annex VIII - Examples for Good Practice Report, Villach, Austria, October 2005. International Energy Agency.

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