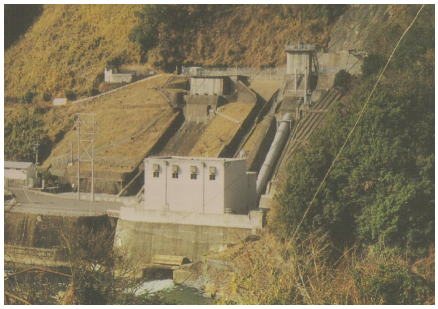
Key Issues: **10- Landscape and Cultural Heritage**



Climatic Zone:
Cf : Temperate humid climate

Subjects:
- Maintenance of installation while attaching importance to restoration of original scenic beauty

Effects:
- Restoration of original natural environment,
- Designing and execution of work by using vanguard technology, and
- Promotion of the community through tourism.

Project Name: Chinda Power Plant
Country: Oita Prefecture, Japan (Asia)

Implementing Party & Period
- Project: Kyushu Electric Power Co., Inc.
1909 (Completion of construction) -
- Good Practice: Kyushu Electric Power Co., Inc.
1998 (Commencement of operation) -

Key words:
Recreation of original beauty, new design method, tourism

Abstract:
Kyushu Electric Power Co., Inc. has successfully developed the practical and systematic engineering method to predict discontinuous rock mass behavior and to evaluate optimum reinforcements by using latest numerical code D.E.M. As the result, the breath-taking view appears again and dam safety is also satisfied. Now, Chinda waterfall is an important resource as a major sightseeing spot.

1. Outline of the Project

The Chinda Hydroelectric Power Plant, situated in Ono-cho in the central part of Oita Prefecture, is a run-off-river type hydroelectric power plant with a maximum output of 8,300kW and a maximum usable discharge of 25.04m3/s (See Fig.-1).

The main stream intake dam of the Chinda Power Plant is in the immediate upstream of a waterfall composed of welded tuff with highly developed columnar and horizontal joints (The Chinda waterfall: 28m in height and 110m in width). The waterfall receded gradually as it repeatedly collapsed whenever the river heavily flooded, and the surface of the falls moved back to directly below the dam apron due to the collapse of rock mass on the surface of the waterfall at the time of the Houhi Flood in July 1990. As the dam was threatened to break if left as it was, reinforcement work on the waterfall was carried out.

The planned engineering work required advanced technology for an effective design of reinforcement work against columnar joint rock mass and safety management for the work to be executed right under highly hazardous base mass. Accordingly, an instant falling-rock sensor was developed

Fig.-1 The Position of the Chinda Waterfall

and advanced technology was employed, aiming at a cost curtailment, improved reliability of reinforcement work and securing the safety during the execution of work. At the same time, serious consideration was given to the restoration of original scenic beauty of the Chinda waterfall.

2. Features of the Project Area

The Chinda waterfall is in the middle courses of the Ono river running across Oita Prefecture and is known as a picturesque place, for example, by the Sesshu's Indian ink drawing, which was produced by the artist during his stay there in the Muromachi Era, about 500 years ago. Today, as a sightseeing spot in Ono-cho, it attracts a number of tourists as well as local inhabitants.

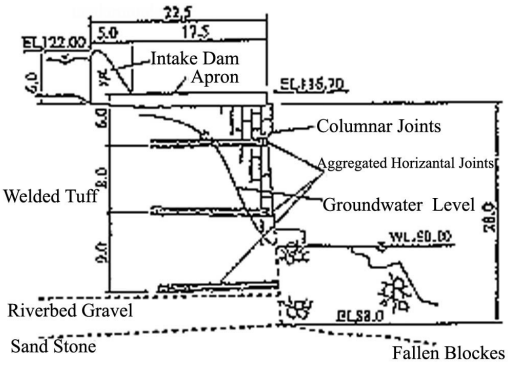


Fig.-2 Geological Profile

3. Major Impacts

Fig.-2 shows geological features of nearly the center part of the waterfall. The falls is composed of welded tuff (Fig.-3) and sandstone of the Mesozoic Era forms the basement. Between them, an unconsolidated sandstone layer, old river bed sediment, deposits in a thickness between 1 and 6 meters. The welded tuff is strongly welded, with the rock mass having an average unconfined compressive strength of 48 MPa but it is a discontinuous rock mass in which columnar and horizontal joints highly developed. The observation of the waterfall surface and boring cores revealed that horizontal joints aggregated densely in three points where they continued at intervals of 10 m or so and that columnar joints had perpendicular continuity at intervals of 1 to 2 m. In the basin of the waterfall, fallen blocks of rock piled up as if they suppressed the foot of the waterfall surface, suggesting that the falls fell down repeatedly in the past. Thus, it was feared that leaving the falls as they were might lead to bursting of the dam situated in the immediate upstream.

Fig.-3 Welded Tuff on the Surface of Waterfall

4. Mitigation Measures

4.1 Landscape Design

Because of its historical background, much was expected of the Chinda waterfall as a local sightseeing resource. A conceptional drawing of the waterfall at the time of completion of work was prepared with the aid of computer graphic and showed to experts of river landscape and river management personnel. In deciding the scale and layout of countermeasure work, these people's opinions were fully taken into account.

4.2 Stability Analysis by Distinct Element Method

The collapse mode of the waterfall being toppling deformation originating in discontinuous surfaces, the distinct element method was used to clarify the collapse mechanism of the falls and to study particulars of effective reinforcement work for designing. Consequently, it was known that when the displacement and rotation of the lower part of the waterfall surface shown in Fig.-3 are restricted, even in a flood with a dam overflow depth of 6m, which might occur at a probability of once in 100 years, downstream toppling deformation of the welded tuff right under the dam apron would be suppressed to maintain the stability of the dam.

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