Construction of Shika Nuclear Power Station
- Focusing on "Harmonization with the Environment" -

Hokuriku Electric Power Company

1. Introduction

Photo 1 : Panoramic view of Shika Nuclear Power Station

Shika Nuclear Power Station is an electric power development project, aim to create a stable power supply and suppress a global warming gas emission for the future in the Hokuriku Area of Japan. This power station comprises two nuclear reactors (Unit No. 1 with an output of 540 MW and Unit No. 2 with an output of 1,358 MW). Since 1988 when the construction of Unit No. 1 was started, a period of eighteen years has been taken to complete the construction of Unit No. 2 (scheduled to start operating in March, 2006). The construction site has a beautiful sea and a reef shore, bringing a lot of happiness and calm to the people. Further inland, it has a spread of rich forest. To proceed with this project, therefore, these natural features had to be preserved while striving to harmonize the nuclear power station with the regional environments, such as the prefectural road closely related to the livelihood of the regional inhabitants, located just in front of the construction site. In this sense, coastal facilities, etc., had their layout determined while proceeding with their design under an unprecedented concept "Facilities with First Priority Given to Preserve the Environment," based on communications with the region.

2. Principle in Layout/Construction Form

Specific principles aimed at harmonizing the Power Station with the nature are as follows:

(1) To leave the shoreline and community road:

Both the intake and discharge of the seawater for cooling in the power station were sited offshore. At the same time, both the intake and discharge channels were tunneled under the sea (Fig. 1). Thus, the seafront nature, including the shoreline, has been preserved while protecting the coastal road, which is not only a community road critical for the locality but also a sightseeing road.

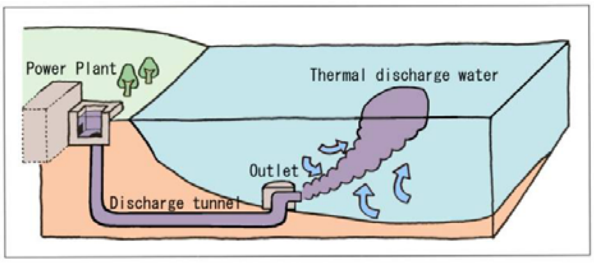

Fig. 1 : Longitudinal view of the discharge tunnel

(2) To preserve marine environments and tidal current:

In the sea area in front of the nuclear power station, the predominant tidal current extends north and south along the shoreline. Harbor equipment would be essential for a nuclear power station to deliver its spent nuclear fuel. If such a harbor should be constructed in the form of a common enclosure-type harbor, it would be necessary to greatly modify the reef-composed shoreline. On the assumption that the harbor should be used year round except for the winter season, harbor facilities were significantly compacted in a combination of straight breakwater and a Dejima-type wharf (Photo 1).

Photo 2 : An abutment with culverts

Furthermore the transportation road was designed to allow for a pass-through of sea water, having its foundation constructed of an abutment with culverts arranged in the crossing direction of the road (Photo 2).

(3) To suppress thermal discharge water spreading range:

To reduce the extent to which the thermal discharge water may raise the seawater temperature, a submarine discharge system was adopted so that the discharge water might be discharged at a high flow rate at a significant depth off the shore of the breakwater (Fig. 1).

(4) To maintain landscape and topology onshore:

The power station had its premises reclaimed in the manner of a staircase, and is stepped to fit the hill, whose altitude increase gradually above sea level from the shoreline. The station's main building was constructed with the lower half in order to suppress the height above ground (Fig.2). In addition, tree-planted embankments were arranged north and south on the premises. The station buildings, therefore, were hidden behind these embankments so that the power station could be 360 degrees surrounded in all directions by green forest (Photo 3).

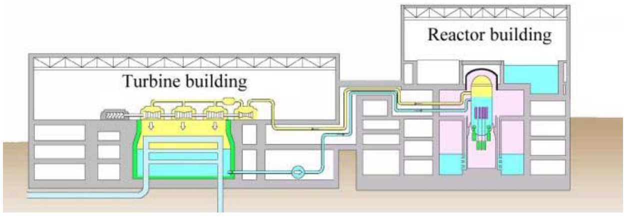

Fig. 2 : The station's main building

Photo 3 : View of the power station from ocean

3. Employing new technologies and new engineering methods in an undersea tunnel:

A variety of new technologies and new engineering methods were used to create the layout and construction form in harmony with the environment. In the following section, the details of the construction technology of a tunnel will be explained as an example of the main technology used.

(1) Employing NATM (New Austrian Tunneling Method) and slurry type shield machine designed for rock:

For the intake and discharge undersea tunnel, the work had to be executed on bedrock that had a very thin overburden and a very high level of water permeability. Consequently, there was a fear that a large volume of water might spring out.

To excavate the undersea tunnel for Unit No.1, the NATM with grouting for dewatering (developed at Sei-Kan tunneling) was adopted for the first time in Japan (Photo 4).

Photo4 : Cannel under construction by NATM

Photo 5 : The slurry type shield machine designed for rock

The undersea tunnel for Unit No. 2, on the other hand, had to be constructed in a long-extended discharge channel created by state-of-the-art tunneling mechanization. This construction work was done on the bedrock with hard and medium-hard rock layers interleaved to an excavation diameter of about 8 meters under high water pressure. To cope with such bedrock, the slurry type shield machine designed for rock, the largest in Japan was employed (Photo 5). As for this method of construction, when the cutter has reached the allowable limit of wear, the cutter that wore off must be exchanged. In case of the exchange, to work with the face where there is much seepage water, the securing of work safety is important. Also, because the work increases, there is possibility that an excavating process is delayed. In order to avoid replacement of the cutter, the dome-type cutter was employed which had a cutting edge made of special steel, having a diameter of 19 inches, the largest in Japan. This improved both durability and abrasion resistance of the cutter. In addition, a durability-improved joint capable of being accurately assembled was employed as segment coupling. This saved the secondary lining while striving to reduce both construction cost and length of time. This engineering method allowed the 730 meter undersea tunnel to be completely constructed in a time frame as short as 8 months without the necessity of grouting for dewatering considered essential to the NATM.

(2) The Shaft construction work Idea; construction out of the undersea tunnel:

To build a shaft in the sea bedrock, a temporary caisson reaching from the seabed to the sea level and a large marine platform are generally employed to execute the work (Fig. 3). This engineering method was used to construct the undersea tunnel for Unit No. 1 with one shaft. Since Unit No. 2 had two shafts, however, that engineering method would be immensely costly on the temporary equipment and there was a fear of significantly affecting the construction time while largely depending upon an oceanic phenomenon.

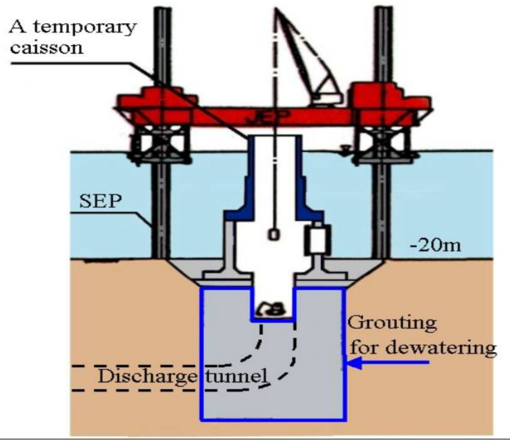

Fig. 3 : Construction of vertical shaft by using the usual method

Therefore after constructing the outlet caisson, a method was thought out to execute all of the works ranging from grouting for dewatering and excavation to concrete lining inside the tunnel.

More specifically, the procedure for executing the work is as follows (Fig. 4):

1) First, use a multi-purpose self-elevating platform (SEP) to cast ground anchors. Then, apply grouting for dewatering.

2) Use the excavator (Photo 6) to excavate upwards so that a heading with a diameter of 2.4 meters may reach the outlet.

3) Use the interior of the outlet as working space to

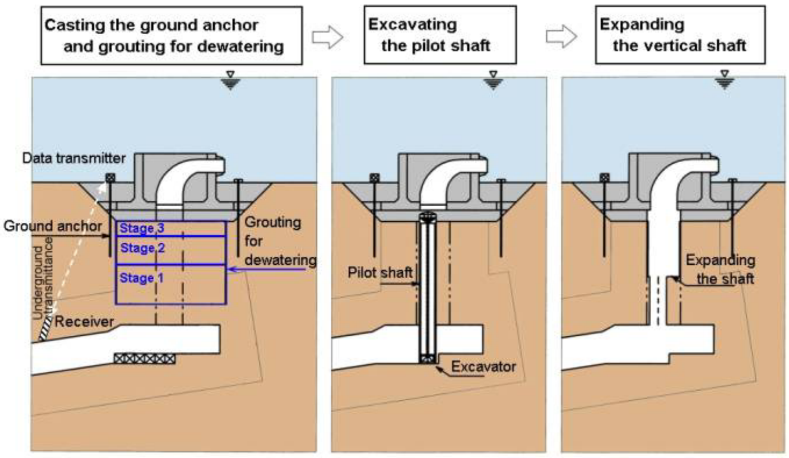

Fig.4 : Construction of vertical shaft by using the new method

Photo 6 : Excavator for the pilot shaft

extend and excavate the shaft up to a section with a diameter of 6 meters. Then, carry out lining.

With this work execution method, there was a fear that the pouring pressure acting upon the caisson on the bottom surface might cause it to go afloat, possibly separating the caisson from the bedrock. Once a separate face has appeared, it will turn out as a new water path that reaches even the seabed. However, it would be difficult to repair the separation, since it cannot be checked from inside the tunnel. So the work was progressively executed under the careful control of pouring. In other words, ground anchors were cast in advance to secure the caisson. Moreover, grouting for dewatering was divided into three stages, and the pouring pressure was restricted especially around stages near the caisson. In addition, to monitor the behavior of the caisson under the influence of pouring pressure by measuring the ground anchors' axial force, we installed the load meters on the ground anchor. Axial force data was electromagnetically propagated under the ground from a transmitter at each measuring point to a receiver inside the tunnel, so that the caisson behavior could be monitored on a real-time basis.

Moreover, the excavator can keep the chamber airtight by opening and closing the double gates installed at the vertical earth discharging pipe. The excavator was also equipped with a dewatering tube to stop water from seeping into the tunnel after the excavator reaches at the bottom of the caisson.

This engineering method is patent pending. It might be considered as an industrial achievement, one which is applicable when executing work in a narrow construction environment or when tunneling in urban areas.

4. Conclusion

Shika Nuclear Power Station is an embodiment of a nuclear power station able to prosperously coexist with in a community while striving to harmonize with the natural environment. This project shows what civil engineering should be like in the future by creating a "positive relationship between Nature and Humans". We hope that the Shika Nuclear Power Station will be considered a significant construction to the development of civil engineering in the future.