Shika Nuclear Power Station Unit No.2 (Shika Unit No.2) is the latest ABWR power plant in the world. Shika Unit No.2 was the first ABWR plant in which all the equipment of the reactor, turbine, and generator were provided by one main contractor, Hitachi, Ltd. In August 1998, as soon as the sanction for the First Construction Plan was given, Hitachi undertook the construction project with safety, reliability, and economic efficiency as construction policies. Thereafter, Hitachi completed the construction, installation, inspection and performance test of the power plant with Hokuriku Electric Power Company starting commercial operation on schedule, March 2006.

In this plant, Hitachi had improved the design quality and applied it to the construction of Shika Unit No.2. Furthermore, leveraging the innovative design and construction technology, Hitachi collaborated with the utility and construction companies in all phases. As a result, Hitachi provided the safest, most reliable, and most economical power plant in the world.

In this article, the innovative technology and methodology leveraged in design and construction phases are described.

1. Introduction

Since the first nuclear plant was constructed in Japan in the 1960’s, fifty-five nuclear power plants have been built, and one more is currently under construction. Hitachi has constructed twenty-two nuclear power plants in Japan so far, and has played an active role in the broad fields of planning, design, procurement, manufacturing, construction and maintenance. Hitachi’s unique technology, such as the 3D-CAD based integrated plant engineering environment, or streamlined design-to-manufacturing system, is playing a primary role in construction. Hitachi applied these technologies and strategies to complete overall construction of the world’s first ABWR.

In recent years, plant construction environment has changed, especially in Japan. For example, the pool of construction workers is smaller and the average age of the workers is greater. Moreover, customers demand costs reduction and shorter construction period. Therefore, achieving greater rationalization in construction was one of the most important issues in the power plant business.

To meet these demands, Hitachi has been developing construction strategies to facilitate domestic nuclear power plant construction since the early 1970s; consequently, Hitachi has made great strides in rationalization. These strategies are the ideal plant construction techniques for further reducing costs, higher quality, improved safety and shorter construction period. We believe that such technology is one of the best solutions for improving the current plant construction environment.

With those excellent strategies applied, Hitachi could construct Shika Unit No.2 as the latest Advanced BWR unit of 1,358MW electrical rated output in the world. In addition, Hokuriku Electric Power Company could safely start the commercial operation of Shika Unit No.2 on schedule, March 2006.

The Shika Unit No.2 was the first ABWR plant in which all the equipment of the reactor, turbine, and generator were provided by one main contractor, Hitachi. Hitachi supplied the entire plant unit from the basic design to the construction, and the commissioning, with the most advanced technology available. The construction started with the foundation excavation of the main building in September 1999, it took 78 months until scheduled commercial operation, and 58 months from the rock inspection to commercial operation. This paper describes the latest technology that Hitachi has applied to the design and construction of the power plant. Besides, the sophisticated design, manufacturing and installation capabilities of Hitachi's strategies are described through the latest construction of Shika Unit No.2.
2. The latest construction technology

2.1 Construction strategy and methodology

In the construction of Shika Unit No.2, the following strategies were implemented:

1. Broader application of large module block construction combining civil and mechanical components
2. Concurrent civil and mechanical work by expansion of carrying major equipment and piping
3. Application of floor packaging construction method
4. Full application of information technology to all of the above and to achieve level-off work load and more efficient construction scheduling.

As a result, we achieved approximately 25% reduction of the maximum work load and improvement of construction procedure in work area, where many construction tasks were operated. Furthermore, construction period was shortened and construction rationalization was achieved while maintaining high safety and quality standard.

In the next paragraphs, the outline of the methodology and technology are described.

2.2 Broader application of large module block construction method

The large module block construction method is one of Hitachi’s construction strategies. This method utilizes large cranes to lift and install large scale modular blocks constructed at the site or pre-assembled in the factory. That makes it possible to bring down construction costs, and to keep to construction schedule.

Hitachi has adopted this advanced construction method since the early 1980’s to the construction of nuclear power plants. In the design, a Computer Aided Engineering (CAE) system is deployed, featuring special module design functions such as automatic center of gravity calculation function and lifting point identification function. Hitachi applied such CAE systems for engineering integration from
design, fabrication, transportation and installation. In addition, dedicated module factory started operations in 2000. By making the best use of these features, more than 200 major modules were designed and built for Shika Unit No.2. An example of a large scale module (RCCV module) consisted of radiation shield, piping and various components, totalling 650 tons. (Ref. Fig. 2) Another example is the central control room module consisting of electrical and mechanical components for punctual construction schedule. Two main steam tunnel modules (55tons each) were fabricated with special features that minimize weld edge preparation and simplify installation and connection work by 3 dimensional data measurement feedback from the site. Hitachi has further optimized the modular construction technology with Shika Unit No. 2 construction.

![Lifting work of the upper drywell module by the large crawler crane](image)

*Figure 2  Lifting work of the upper drywell module by the large crawler crane
This figure shows Lifting of the 650ton upper drywell module being installed into the RCCV (Reinforced Concrete Containment Vessel), by the large crawler crane.*

**2.3 Concurrent civil and mechanical work by expansion of carrying major equipment and piping**

In the construction of Shika Unit No.2, the target and amount of pre-transported components were expanded by detail consideration with building company. Several kinds of work, which were heretofore implemented after complete change of construction jurisdiction from building company to installation company, could start before the jurisdiction change. The targeted works were installation of equipment, control panels, equipment foundation, mounting bases, lighting and power cabling, deck plate work, monorail installation, valve lifting and installation, and instrument racks. Thus, the concurrent work led to levelling off the workload and improving the efficiency of the work on site.

**2.4 Application of floor packaging construction method**

Generally, hydro pressure testing in power plant systems is implemented after completing the system construction. However, this construction method allows to carry partial hydro pressure testing before completion of whole system construction. After completing construction in each floor, the partial pressure testing is undertaken in the range of closed area. Therefore, the work area can be sequentially closed from the bottom floor, which helps a great deal in improving work efficiency and leveraging off the maximum work load. (Fig.3)
2.5 Integrated Construction Management with Information Technology

(1) Application of Advanced Technology and 3-dimensional CAD over the entire plant design and work plan

Hitachi applied Computer-Aided-Design using the latest computer technology to the plant arrangement and layout design for Shika Unit No.2. By fully applying an improved system compared with the previous power plants, Hitachi achieved more sophisticated plant layout and piping layout design. For example, the advanced CAD system allowed engineers to more easily allocate adequate operational space, equipment disassembly space, and temporary storage space for equipment. (Ref. Fig. 4)

Furthermore, the CAD system made it possible to simulate machines disassembly and inspection during the design phase. This feature resulted in centralization of plant data information management, improving an advance work plan for inspection, and allowing engineers to identify interferences between components during construction. (Ref. Fig. 5)

The application of such advanced CAD system made the plant layout design more efficient and accurate. In addition, its simulation system leveraging graphics function improved the accessibility and availability of certain equipments and facilities during construction. Simulations also made it easier to confirm the transport paths of disassembled equipments and to examine the transport procedures. Thus, Hitachi obtained the technology to plan and design promising power plants with the 3-D CAD system as well as to optimise the layout.
Figure 4   Examination of area layout
This figure shows the examination of the area layout, with inspection space and equipment disassembly space, using 3D-CAD. This kind of simulation made it possible to plan rational layout during the design phase.

Figure 5   Examination of equipment disassembly simulation
Using 3D-CAD makes it possible to visualize the work-procedure and to detect the interferences between components under installation.

(2) Establishment of a local network
By establishing an entire computer network between department offices, manufacturing facilities, and site offices, centralization of plant data information management, timely information exchange, and communication were achieved. Furthermore, the site office was directly connected to each major construction area (Local Satellite) for better interactive communication. The communication network made it possible to communicate and download any design document at the local satellite office. (Ref. Fig. 6)
(3) Development and Introduction of an integrated construction management system (ICMS)

Under construction of a nuclear power plant, countless equipments are managed. Therefore, detailed planning before the actual work commencement, punctual delivery of products, just-in-time delivering of documents, early acknowledgement of any discrepancy between plan. Implementation and early rectification of such discrepancies are essential for efficient construction. To support those works, and fulfill proper and timely site construction management by sharing information on site and showing site works in work flow form, ICMS was developed and introduced on site. Furthermore, new functions were added to the management system applied to Shika Unit No.2 construction, such as a support function of jurisdiction change to commissioning, a management function of remaining work in site, and so forth. Applying the integrated management system, Hitachi achieved a consistent site management during the whole construction work.

3. Conclusion

This paper describes Hitachi’s advanced construction technology for Shika Unit No. 2 of the Hokuriku Electric Power Co., Inc. Hitachi completed a set of reactor, turbine, and generator facilities of Shika Unit No.2 in all phases of design, construction, and commissioning. During this construction Hitachi further developed expansion of modularization, concurrent civil and mechanical work, floor-packaging construction method, and integrated construction management. As a result, thanks to its accumulated experience and innovative technology, Hitachi was able to supply the latest power plant that meets social requirements about reliability and economic efficiency.

Hitachi is committed to continue its technological development and provide economical, safe, and reliable nuclear power generation systems in the future.

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5. References