

Advanced Construction Technologies and Further Evolution Towards New Build NPP Projects

Junichi Kawahata, Kouichi Murayama, Hitachi-GE Nuclear Energy, Ltd., Hitachi/Japan
Kenji Akagi, Hitachi-GE Nuclear Energy, Ltd.
junichi.kawahata.hh@hitachi.com

Abstract. Shika Nuclear Power Station Unit No.2 began commercial operation in March 2006 as one of the latest new-build projects in the world. Hitachi-GE Nuclear Energy Ltd. (Hitachi) was the main contractor and supplied the entire plant including engineering, manufacturing of all major reactor and turbine-generator components, and executed the installation and commissioning. Hitachi completed the project on schedule and on budget owing in large part to its highly reliable advanced construction technology. This article describes Hitachi's unsurpassed advanced construction technology being applied to the current new-build projects in Japan.

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 plant is currently under construction by Hitachi. Hitachi has constructed twenty-two nuclear power plants (NPPs) in Japan to date, and has played an active role in the field of nuclear power plant construction. Using Hitachi's advanced technologies, which include unique 3D-CAD based integrated plant engineering environment and streamlined design-to-manufacturing/construction management systems, play integral roles within the great achievements of past NPP projects. In Japan, another ABWR project, Shimane Unit-3, is steadily being constructed for "On-Budget and On schedule" now, where Hitachi is taking main role as the same as at the Shika-2 and more advanced design and construction methodologies are being applied.

Over the last few decades, the plant construction environment has changed in Japan dramatically. For example, the pool of construction workers has gotten smaller and smaller, while the average age of workers has increased. Moreover, customer demands for costs reduction and shorter construction periods continued to become stronger. Therefore, achieving greater rationalization in construction is one of the most important issues in power plant business.

To meet these demands, Hitachi has developed construction strategies based on the abundant feedback gained from NPP construction experience and has made great strides in the rationalization and application of this feedback into its strategies. The strategies, are "Reduce on site work volume", "Leveling on-site manpower", "Improve on-site work efficiency", and "Improve on-site administrative work efficiency", and these concepts are very simple in principle, however, their effectiveness has been absolutely proven through the successes of the past projects. In addition, Hitachi believes their strategies are equally applicable to any and all power plant projects.

Utilizing all of Hitachi's accumulated technology, one of the world's latest new-build projects, Shika Unit No.2 (Shika-2) of Hokuriku Electric Power Company with 1,358MW electrical rated output, was constructed "On-Budget and On-Schedule".

The Shika-2 was the first ABWR plant in which all the major equipment, including the reactor, turbine and generator, were supplied and constructed were provided by one main contractor, Hitachi. As well, Hitachi took responsibility for the entire plant engineering support from the basic design through to commissioning. The construction started with the foundation excavation of the main building in September 1999, and 58 months following rock inspection, the plant was declared in commercial operation in March 2006.

In Japan, another ABWR project, Shimane Unit-3, is steadily being constructed for “On- Budget and On schedule” now, where Hitachi is taking main role as the same as at the Shika-2 and more advanced design and construction methodologies are being applied.

The world market currently faces the Nuclear Renaissance and this causes strong demand for many NPP constructions all over the world. To well manage and implement “Construction” itself is crucial for project costs, in other words, overall nuclear economic efficiency. Therefore, HGNE commits to apply advanced construction methodologies in plant design, construction planning and management technology described herein to future NPP projects abroad.

2. APPLIED CONSTRUCTION TECHNOLOGIES

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

- Broader application of large module/block construction methods
- Open-top and Parallel Construction method
- Application of floor packaging construction methods
- Full application of information technology to quality plant engineering and construction achievements

As a result, there was an approximately 25% reduction in the peak work load at site achieved due to these improvements to construction procedures in work areas where many construction tasks take place operated, were implemented.

From the next paragraphs outlines the methodology and technology used to accomplish this reduction.

2.1. Broader application of large module/block construction method

Large module/block construction method is one of Hitachi’s construction strategies. This method utilizes heavy-lift crane to lift and install large scale modules/blocks which can be constructed at either site or a module shop.

Hitachi has employed this method since the early 1980’s to the construction of nuclear power plants, with a total number of about 900 modules experienced so far. During the design, a Computer Aided Engineering (CAE) system is fully deployed with special features dedicated to a specifically for module engineering (such as automatic center of gravity calculation and assembly planning). Hitachi routinely applies this specialized CAE systems to the overall module engineering, and constructed a dedicated module factory in 2000 which is fully integrated with the CAE system. By making the best use of these assets, about 200 modules were designed and built for Shika-2. The RCCV upper drywell module is one of great achievements of 200 modules, which consisted of pipe whip restraint structure, radiation shielding, piping, valves and other components in the drywell and totalling 650 metric tons.

2.2. Open-top and Parallel Construction method

“Open-top and Parallel-Construction method” is often applied to NPP construction in Japan now, and it was applied to Shika-2 without hesitation. In the most basic aspects, in this method construction work of both civil and mechanical disciplines are conducted in parallel with mutual agreements of scope of work, and major components to be installed in the area are carried in prior to the ceiling work of that area being installed. After the curing of concrete in the ceilings and walls, the installation work within the target area starts. At the same time, major components are brought into the upper floor level. Thus during the construction of the building civil structure, mechanical/electrical installation work can proceed which therefore, enables a levelling off of manpower peak at the construction site. As one may expect, since various activities are implemented at the same time, this method requires very detailed coordination between civil contractors and mechanical/electrical installation companies including delivery control of components.

2.3. Application of floor packaging construction method

Traditionally, hydro-static pressure testing in completed power plant systems needs to be implemented after the completion of system construction, which inevitably led to work loads peaking at or near the end of construction. Hitachi has developed a new concept for this issue, named “Floor Packaging method”, which allows partial hydro-static pressure testing prior to 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 of leveraging off the maximum workload.

2.4. Full application of information technology to quality plant engineering and construction achievements

- Application of Advanced Technology and 3-dimensional CAD over the complete plant design and work plan

Hitachi has applied Computer-Aided-Design using the latest computer technology to the plant arrangement and layout design for Shika-2. By fully applying an improved system compared with the previous power plant designs, more sophisticated plant and piping layouts were enabled. For example, the advanced CAD system allowed engineers to more easily allocate adequate operational space, equipment disassembly space, and temporary storage space for equipment. 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 the advance work plans for inspection, and allowing engineers to identify interferences between components during construction.

The application of this advanced CAD system made the plant layout design more efficient and accurate. In addition, its simulation function helped leverage practical engineering for accessibility, constructability and maintainability. Simulations also made it easier to confirm the transport paths of disassembled equipment and to examine the transport procedures. From a variety of different perspective, quality design and highly efficient work were achieved.

3. DEVELOPMENT OF ADVANCED TECHNOLOGIES

Hitachi is currently constructing new-build projects in Japan now. For this project, more advanced technologies beyond those applied at Shika-2 are developed and introduced. Application of RFID (Radio Frequency IDentification) is one of more advanced technologies. RFID is a technology which allows contactless recognition to obtain the information stored in the integrated circuit using an electronic reader and transmitter, and it has more advantageous features than barcode, which include better anti-counterfeit features and invisible recognition.

For NPP construction, it is imperative that precise and accurate traceability methodology are employed required, therefore significant manpower were traditionally spent at every project for this purpose. In the aim for more efficient and quality construction work, a more rational, less labour intensive strategy was required.. Therefore, by utilizing the RFID key features, Hitachi initiated the development and application of RFID systems to NPP construction. In this section, some of the application plans for RFID are described.

- Application to Product Control Subsystem

Conventionally, product was shipped from factory with an identification label on product and added to a shipping information list for use at site. On the arrival of the products at site, a work foreman would identify those products by checking the label attached on the products and comparing the information to that contained on the shipping list, and then manually record the results into the database as to

which components had been delivered to site. This required a lot of time and effort to ensure product management.

In the newly developed system, product labels containing RFID are attached to the product at factory, and the product ID and RFID number are automatically linked to the database system. The work foreman can now easily identify products by reading the RFID information using a handheld reader, and the result can be transferred to the database. In order to apply RFID to NPP construction, significant research and studies were performed to ensure the RFID technology would operate as expected under the extreme environmental conditions which could be present at a construction work site.

- Application to Construction Work management

Piping at a construction work site is typically managed by the relevant welding points, and the work record would be manually prepared and input to the database. For the improvement of this process, Hitachi also applies RFID technology to the welding process. With the newly developed systems, work instruction can be obtained by just pointing a PDA with a reader to the RFID on the piping to be welded, and the work records can be easily input via PDA adding worker ID and tool/instrument ID (which are also identified by their associate RFID). As well as improvement of the preparation of work record efficiency, this has led to a decrease in human errors in recording work completion and allows for rapid updates to work progress reports.

4. CONCLUSION

This paper describes Hitachi's achievements for Shika Unit No. 2 of the Hokuriku Electric Power Co including various advanced construction technologies. In addition, more advanced construction technology being applied to the upcoming new-build projects in Japan is also described.

Although Hitachi's technology and experience have been cultivated through BWR projects, their practical engineering capability and methodology can be equally applied to overseas NPP projects as well.

Hitachi is confident that it can contribute to execution of new-build nuclear power plants by exercising relationship with quality partners. Hitachi is also convinced that overseas companies will appreciate Hitachi's advanced construction technology which is already proved to be most powerful tool for new-build projects construction/implementation.

Hitachi is committed to the endeavour for further development of advanced construction technology and to provide more economical, safe, and reliable nuclear power generation systems to all over the world in the coming nuclear renaissance.

6. ACKNOWLEDGEMENT

In the development and application of Hitachi's construction strategies and technologies, Hokuriku Electric Power Company and the Chugoku Electric Power Co, Inc. of Japan have given a lot of good suggestion and advice. They have really helped and inspired our achievements. We sincerely appreciate the cordial help of other companies with good faith.

REFERENCES

- [1] S. Yamanari, et al, "The development of a comprehensive integrated nuclear power plant construction management system", Hitachi Review, Vol.88, Iss.2, 2006.2, pp.173-178
- [2] K. Morita, and K. Akagi, et al, "Advanced Construction Technology for Shika Nuclear Power Station Unit No.2 of the Hokuriku Electric Power Company", Proceedings of the 15th Pacific Basin Nuclear Conference (PBNC) Sydney, Australia, 2006

- [3] K.Akagi and S.Akahori, et al, “The Latest Application of Hitachi’s State-of-the-art Construction Technology and Further Evolution Towards New Build NPP Projects”, Proceedings of the 29th Annual Conference of the Canadian Nuclear Society (CNS) 2008