XA9848584

ADVANCED PLANT ENGINEERING AND CONSTRUCTION OF JAPANESE ABWRs

N. GOTOH, J. SUMIKAWA, N. YOSHIDA, M. YOSHIDA
Nuclear Plant Engineering and Construction Department,
Hitachi Works, Hitachi Ltd,
Ibaraki, Japan

Abstract

Remarkable improvement -has been made in recent nuclear power plant design and construction in Japan. These many improved engineering technologies has been made a good use in the lately commercial operated two world's first 1,356MWe ABW's (Advanced Boiling Water Reactors), and made a great contribution to the smooth progress and the completion of the highly reliable plant construction. Especially, two engineering technologies, (l), three-dimensional computer aided design system through engineering data-base, and (2), large scale modularising construction method, have been successfully applied as the -integrated engineering technologies of the plant construction.

And two integrated reviews, "integrated design review, confirmation of new and changed design and prevention of failure recurrence" in the design stage, and "constructing plant review" at the site, have been widely and systematically conducted as a link in the chain of steady reliability improvement activities.

These advanced and/or continuous and steady technologies are one of most important factors for high reliability through the entire lifetime of a nuclear plant, including planning, design, construction, operation and maintenance stages.

1. INTRODUCTION

In Japan, continuous efforts have been made to improve the design, the construction, the operation, and the preventive maintenance technologies applied to nuclear power plants. Consequently, high reliability through the entire plant lifetime has been featured, and a higher load factor, a smaller unscheduled outage number and a shorter periodical inspection time have became possible in Japanese nuclear power plants.

Various high and improved technologies based on past experience, research and development and accumulated data were certainly applied to the design, the construction and the plant data management of Japanese two 1,356 MWe ABWR power plants which began commercial operation on Nov. '96 and July '97. The construction of these plants are recognized to have completed with high quality and reliability.

Especially, from the viewpoint of plant design and construction engineering,

- three-dimensional computer aided design (3D-CAD) system with engineering data-base
- large scale modularizing construction method using large capacity lifting device

are worth giving attention as successful technologies.

And in Hitachi, the high quality engineering and the reliability improvement activities have been continuously performed using computerized "Integrated Reliability

Management System for Nuclear Power Plant" with centralized managed data-base, and two integrated reviews ,

- integrated design review
- constructing plant review at site

from various viewpoints at some key stages have been systematically conducted as a part of those activities in CO-operation with each other of design, fabrication, construction and quality assurance (QA) sections.

This paper describes these outlines, features and some examples as follows.

2. IMPROVED TECHNOLOGIES FOR PLANT DESIGN AND CONSTRUCTION

2.1. Three-dimensional Computer Aided Design (3D-CAD)

At present, what is called " 3D-CAD system" is widely applied to nuclear power plant layout design in which objective plant facilities are visually modeled by using three-dimensional computer graphic function.

Though there are some general-use 3D-CAD systems in the world, Hitachi have practically used own developed and customized system functionally reflected own plant design practice. The system configuration is shown in Figure 1. The centralized managed design data in engineering data-base easily enable wide and effective data applications, for instance preventive maintenance planning (accessibility, maintainability, etc.) and construction work planning (installation procedure, equipment set-on /carry-in, temporary scaffolding, etc.). The 3D-CAD system with engineering data-base has became indispensable to the high quality plant layout design.

Particularly, the carefully considering and executing items using this system at the design stage with the intention of putting the higher reliability into operating plant are as follows.

(1) To insure the passability and the accessibility

・・・the indication of pass and access space on graphic model, the restriction of arrangement planning into those spaces, and the confirmation of these abilities by simulation function (Figure 2)

(2) To insure the operability, the maintainability, and disassembly / inspection ability

・・・the indication and confirmation each needed spaces same above, and the check & review by maintenance / inspection staffs (Figure 3)

(3) To insure the easiness and/or reasonableness of installation procedure

・・・the indication of site work points (weld point, interference point, etc.), and the check & review and the work planning by work staffs

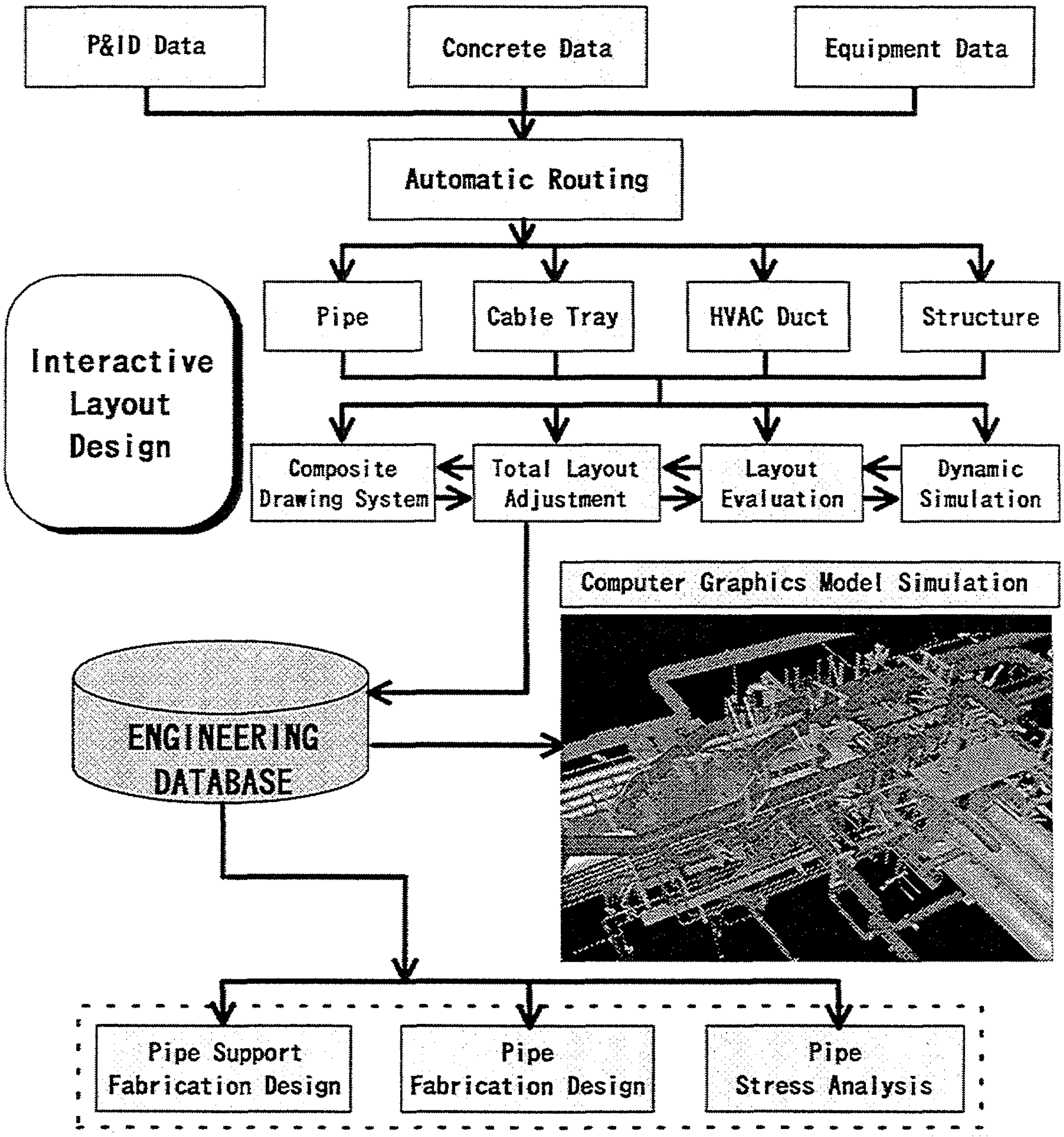

FIG. 1. System Configuration.

And, the 3D-CAD design with high accuracy and the application technique of consistently managed data in the engineering data-base enable to adopt the large scale modularization method in the construction stage shown in following section.

This engineering data-base is very effective to not only plant design and construction but also plant data management, preventive maintenance, and improving design, etc. (Figure 4), and its widely practical use through the entire lifetime of a nuclear plant will be greatly expected.

2.2. Large Scale Modularization Method

There is a modularizing construction method in which each parts are pre-fabricated and combined up to adequate size at factory, yard, and in-site assembly area, etc. instead of

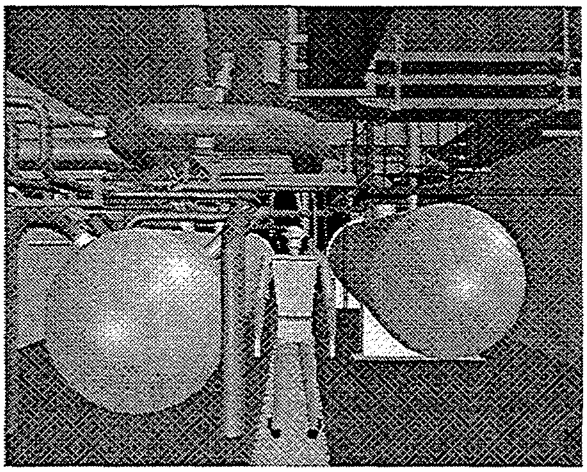

FIG. 2. Access Simulation.

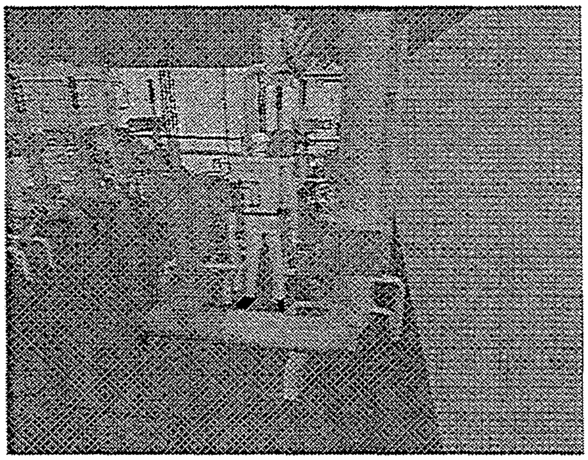

Fig. 3(a). Operability Review.

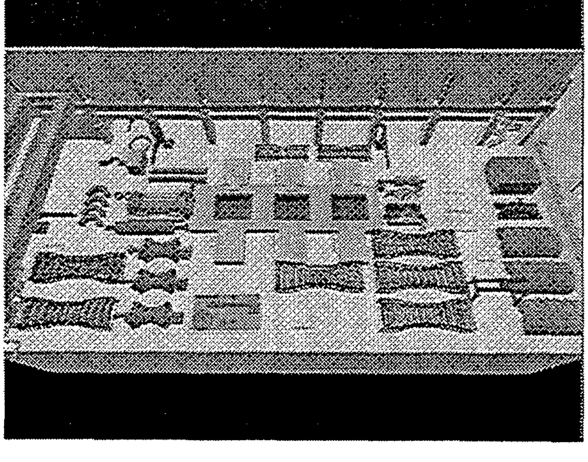

FIG. 3(b). Equipment Removal Simulation.

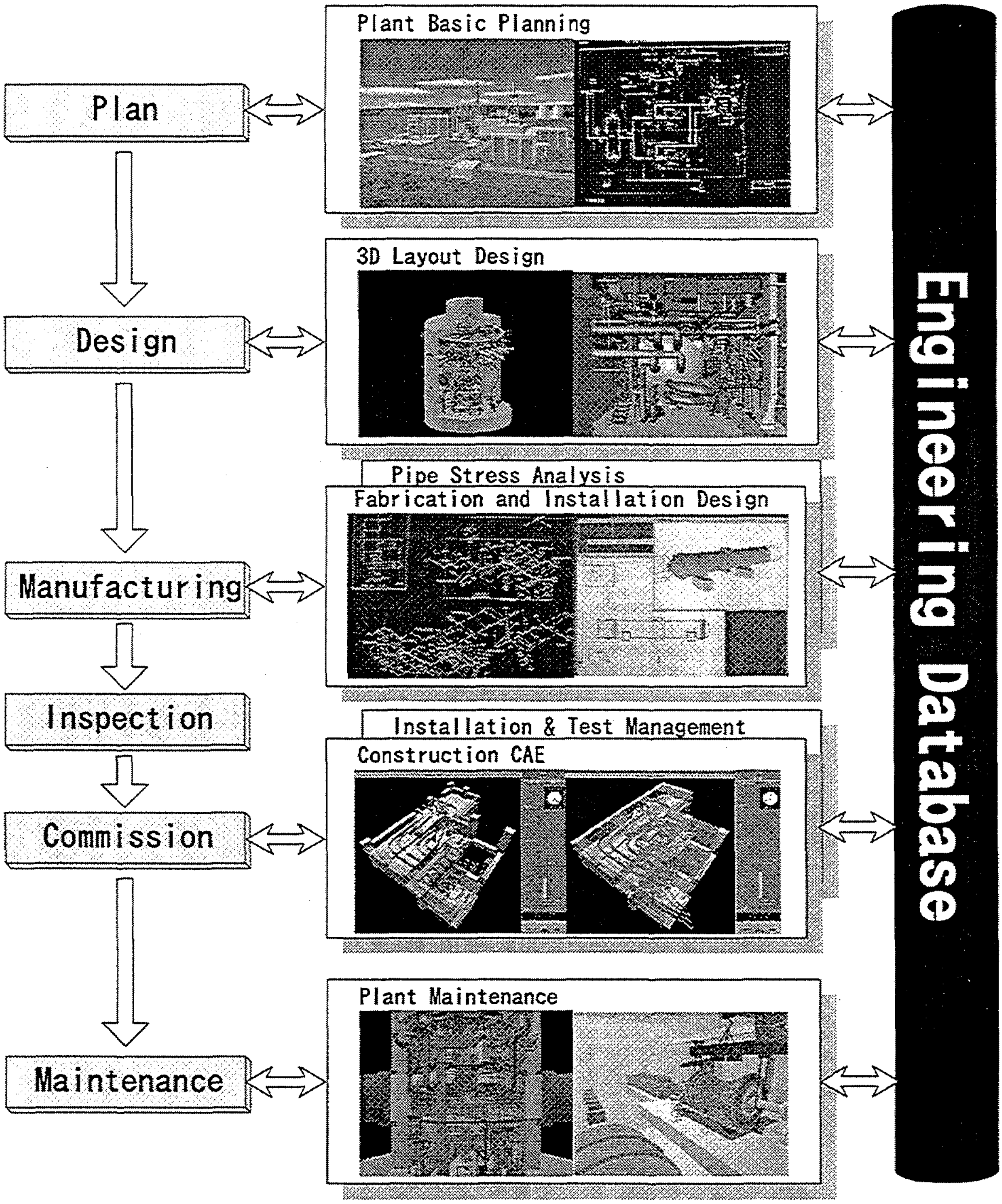

FIG. 4. Plant Integrated CAE System.

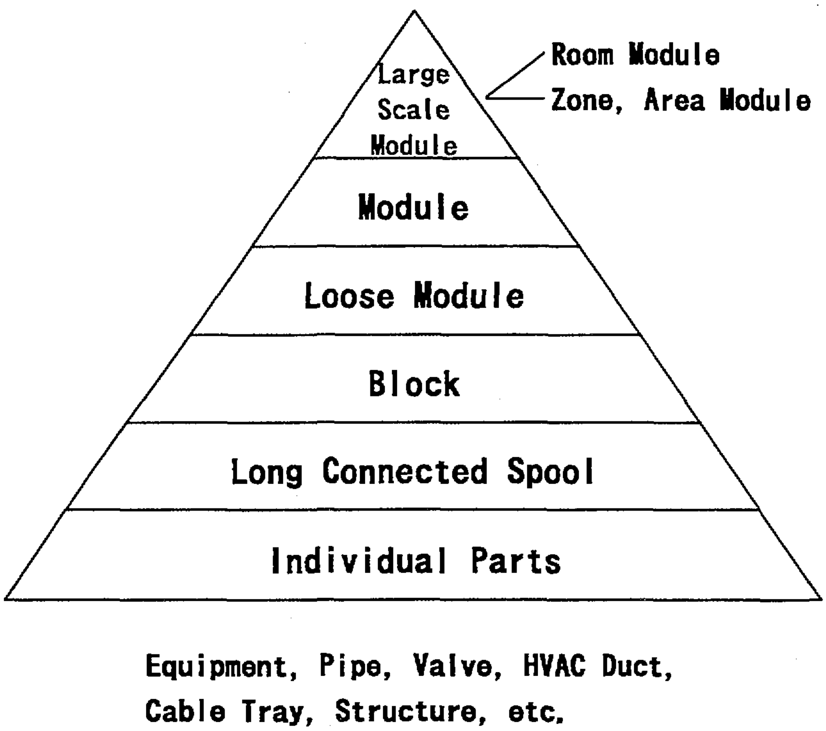

FIG. 5. The Concept of Modularization.

conventional method constructing each parts by parts at the final setting point. In the "Large Scale Modularization Method", each parts are more pre-fabricated as larger and/or higher completed as practicable, and lifted up at a stroke and down to final installation point using a large capacity lifting device.

The merits of the modularization from the viewpoint of plant reliability improvement are summarized below.

- To obtain higher quality and accuracy through better conditioned work (workability, fabricating devise & tool, and other surroundings)
- To average human resource and resultantly preserve quality potential

Also considering other purposes and merits, the expansion, the size enlargement and the higher pre-completion of modularization are being oriented. The concept and the actual results of modularization are shown in Figure 5 and 6 respectively. Especially, super large scale module, whole room module and combined module with civil parts are situated at the top of the concept of modularization, and to be standardized in future nuclear plant construction.

This large scale modularization is accomplished by using large capacity lifting device (e.g. 1,000 ton cap. giant crawler crane or 130 ton cap. tower crane) in addition to related various technologies such as high accurately optical measuring of interface point with the strong support of 3D-CAD design.

Outlined below are typical results of the modularization.

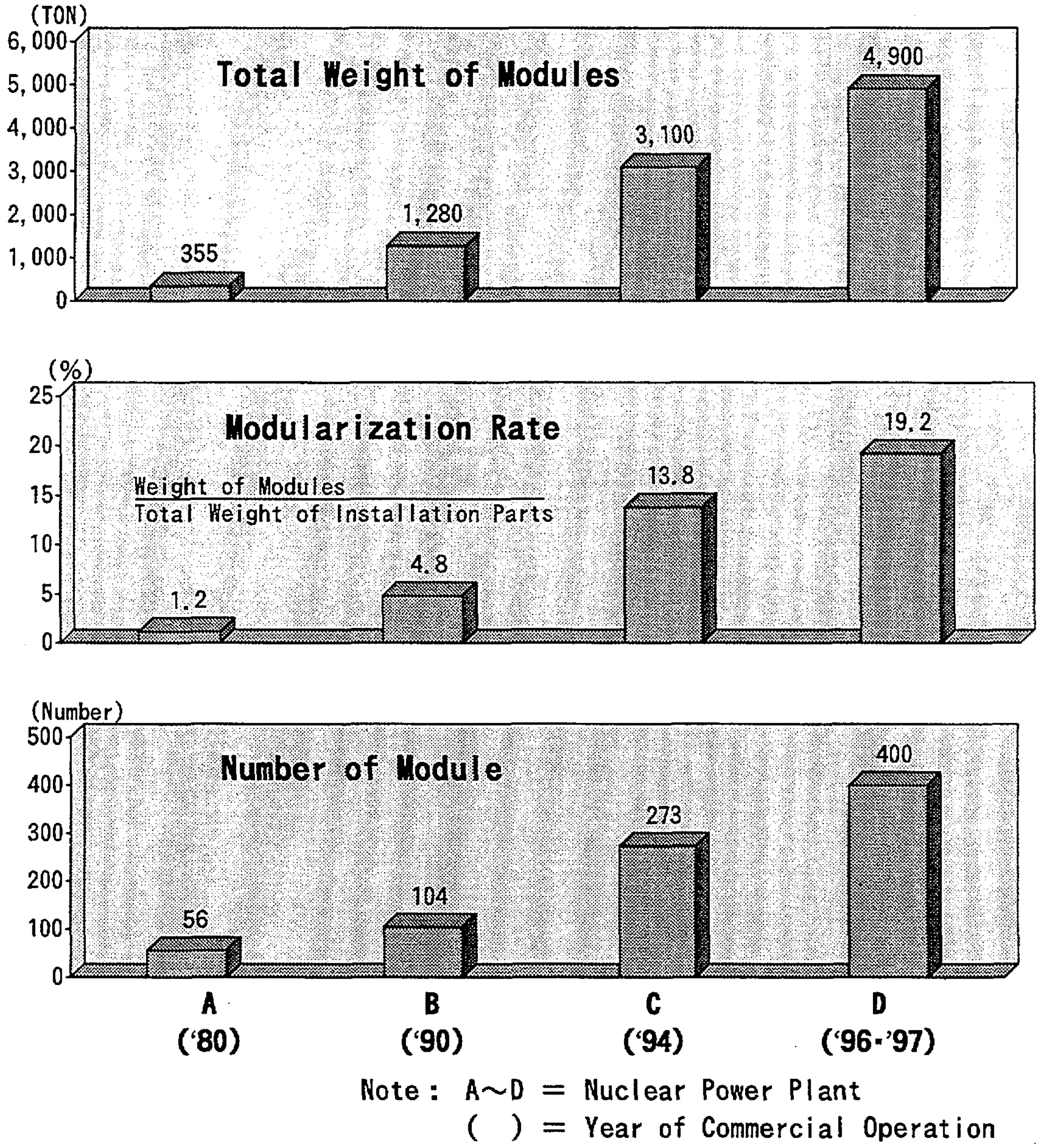

FIG. 6. Actual Result of Modularization.

(1) Upper Drywell Super Large Scale Module

This is the heaviest and most complicated module for the purpose of the avoidance of critical pass and the high quality fabrication under good condition. It consists of γ-shield wall, pipes, valves, cable-trays, air-ducts and their support structures, and weights 650 tons. (Figure 7 ,8)

(2) Whole Room Module

Two rooms were successfully modularized with the combination of civil structures, rebars and mechanical / electrical equipments and parts (weight: 300 tons and 440 tons). (Figure 9)

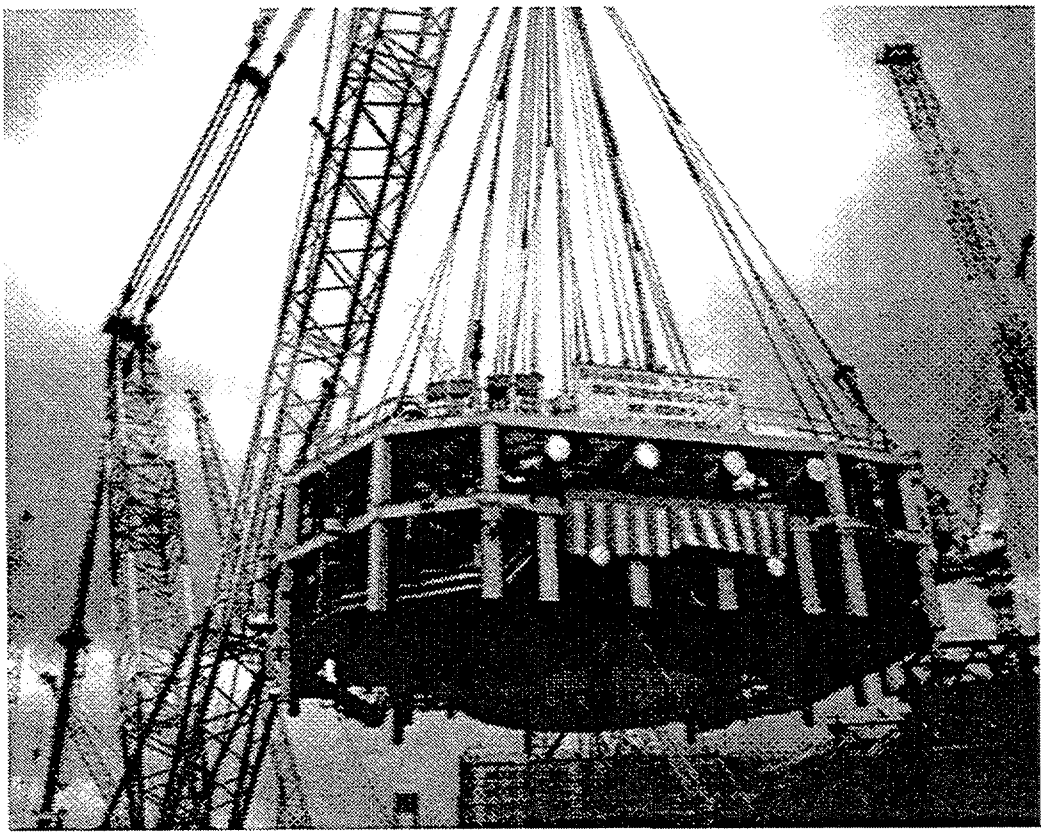

FIG. 7. RCCV Module.

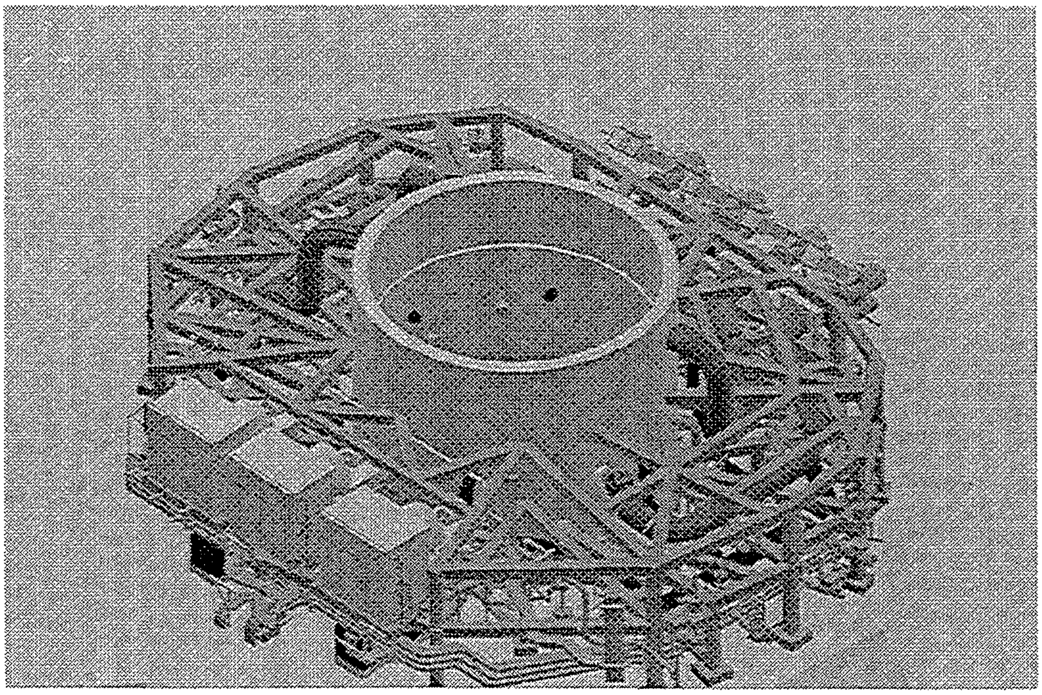

FIG. 8. RCCV Module CAD Model.

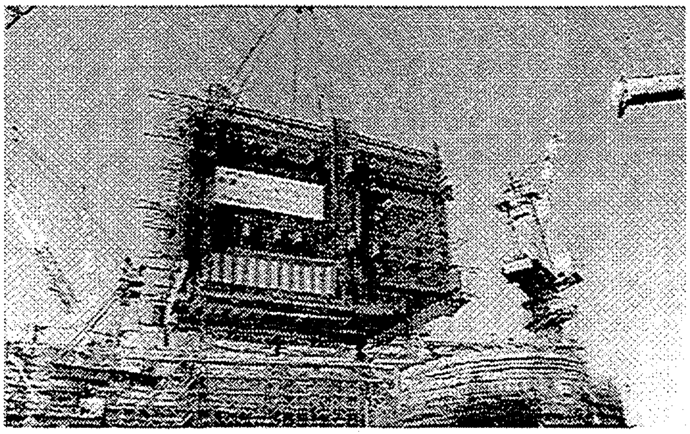

FIG. 9. Room Module.

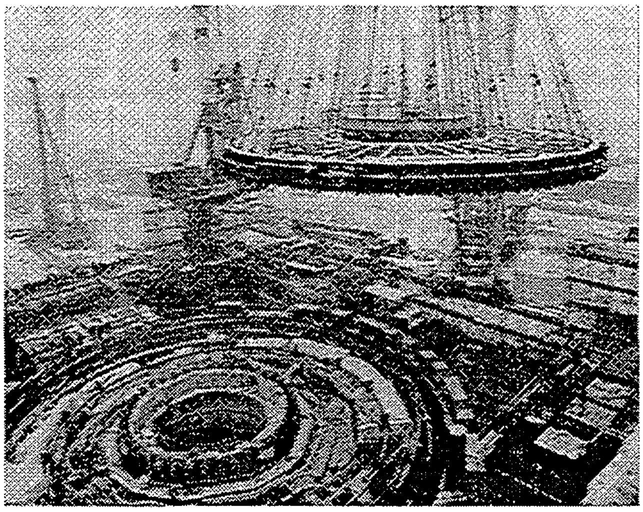

FIG. 10. Top Slab Module.

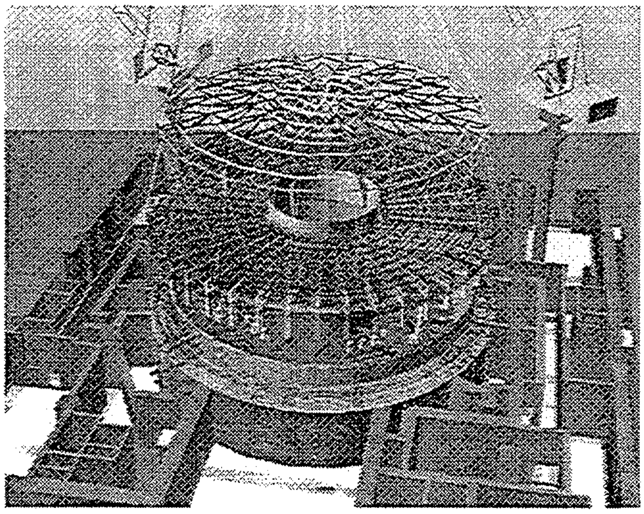

FIG. 11. Top Slab Module CAD Model.

(3) Reactor Building Center Mat Module and RCCV Top Slab Module

These two complexly overcrowding parts, a combination of civil structures, rebars, and mechanical equipment foundation, were formed into large modules in a yard adjacent to reactor building, and carried onto the each locations. (Figure 10, 11)

The above (1) is featured as super large scale and high completed and (2), (3) are civil combined modules, and again, the modularization is oriented as the one of most effective method in future nuclear plant construction.

Additionally, structural simplification of nuclear plant buildings to be easily modularized will be a important theme to be realized in the future.

And for reference, general ideas of improvement of new and future plant construction including the modularization method are shown in supplemental figure and table.

3. RELIABILITY IMPROVEMENT ACTIVITIES FOR NEW CONSTRUCTING PLANT

3.1. Integrated Design Review

The reliability of each design is insured through activities based on the quality assurance system for nuclear plant construction. The " Integrated Design Review" is a re-check of design contents on the final design stage with informed people, and concretely, these two items,

- contents of prevention of failure recurrence
- contents of new and modified design

are mainly confirmed.

(1) Confirmation of prevention of failure recurrence

In the integrated design review, the status of previous failure prevention which is counter-measured and/or re-designed at each design stage is reviewed in a sense of final check.

(2) Confirmation of new and modified design (design change)

New designs and/or design changes are usually done on account of the development and the improvement of system, equipment and various technologies, and site unique conditions. The status of activities to prove the appropriateness of those design changes is reviewed in the integrated design review.

3.2. Constructing Plant Review at Site

The integrated site review on some key stages of construction progress are conducted with related sections, and pointed out facilities are modified if needed. Those key stages and review contents are shown below.

- Before 6.9 kv power receiving

  ・・・prior check of power related facilities preparatory to first power receiving

- Before reactor pressure vessel pressure test
  - · · · general check of installed mechanical equipment and facilities at the peak time of constriction work
- Before fuel loading
  - · · · general check of installation completed plant facilities
- Before commercial operation
  - · · · general check of plant facilities during or after partial and/or full power test operation

In addition to two integrated reviews above, the task force activities are practiced to check and review procedures and results of various start up tests. To effectively manage and control these many plant reliability related data and information, the computerized "Integrated Reliability Management System for Nuclear Power Plants" are being functionally operated as a supporting tool of reliability improvement activities.

4. SUMMARY

To improve availability and reliability of nuclear power plant, it is quite necessary that reliability related items and technologies are considered and potentialized into design and construction work with taking account of the entire plant lifetime. From this viewpoint, our improved technologies applied to the lately commercial operated world's first ABWRs' design and construction are outlined above.

Conclusively, under continuous reliability improvement activities, 3D-CAD plant layout design with engineering data-base and large scale modularization method with large capacity crane are greatly effective for reliable plant design and construction, and they, therefore, should be more improved and rationalized as one of major technical field in nuclear plant engineering.

SUPPLEMENT

		THEME	MEASURE
SHORTENING OF CONSTRUCTION SCHEDULE AND IMPROVEMENT OF RELIABILITY	CONSTRUCTION ENGINEERING & TECHNIQUE	● ADVANCEMENT OF CONSTRUCTION PLANING ● REDUCTION OF ON-SITE WORK VOLUME ● MAXIMIZATION OF CONCURRENT WORK OF CIVIL AND MECHANICAL CONSTRUCTION ● IMPROVEMENT OF THE QUALITY AND RELIABILITY OF CONSTRUCTION	● DEVELOPMENT OF ENGINEERING TOOL FOR CONSTRUCTION ● MAXIMIZATION OF BLOCK PREFABRICATION ● COMPOSITE CIVIL AND MECHANICAL MODULARIZATION ● AUTOMATION OF ON-SITE WORK
	CONSTRUCTION MANAGEMENT	● RATIONALIZATION OF CONSTRUCTION MANAGEMENT	● UNIFICATION OF INFORMATION BETWEEN WORKS AND SITES

IMPROVEMENT OF THE PLANT CONSTRUCTION

Table IMPROVEMENTS OF NEW CONSTRUCTION TECHNOLOGY

VIEWPOINT	NEW TECHNOLOGY
MAXIMIZATION OF CONCURRENT WORK	● RPV DIRECT-ON BY SUPERLARGE CRANE ● Q-DECK SYSTEM FOR FLOOR SLABS ● PREFABRICATED STRUCTURAL UNITS FOR MAIN CONTROL AND ELECTRIC PANEL ROOM ● POOL LINING UNITS ● COMPOSITE CIVIL AND MECHANICAL MODULARIZATION ● T-G PEDESTAL BEAM AND ANCHORBOLT MODULARIZATION ● CONCURRENT WORK OF CIRCULATING WATER PIPE AND BASEMAT
REDUCTION OF ON-SITE WORK VOLUME	● VERTICAL EXCAVATION METHOD (TIE-BACK TECHNIQUES) ● PREFABRICATION OF REBARS ● PREFABRICATION OF LARGE SCALE PCV BLOCKS ● STRUCTURE, EQUIPMENT AND PIPING MODULARIZATION ● EXTENSIVE APPLICATION OF BENDING PIPE
IMPROVEMENT OF WORK PRODUCTIVITY	● AUTOMATIC CABLE PULLING MACHINE ● AUTOMATIC WELDING MACHINE ● AUTOMATIC TUBE LOADING MACHINE FOR CONDENSER