Basic study on module technology for shortening i-SMR construction period: Effect of Modularization by Construction Package

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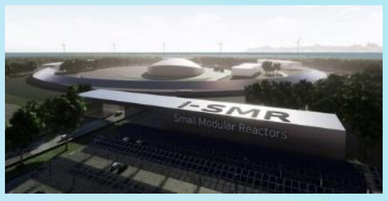
Introduction



- Research on i-SMR construction methodologies, especially modularization, is limited.
- This study analyzes Modularization technology for i-SMRs using APR1400 experience and highlights its advantages in Construction Package and Critical Path.

Background

2.1 Construction Package

- The Construction Package (CP) system in the APR1400 is structured to systematically divide the various construction processes, ensuring an organized and efficient approach to the construction of NPPs [1].
- The construction framework of the APR1400 consists of 20 packages, labeled from CP-C1 to CP-E4.

2.2 Critical Path of APR1400

- Critical Path is a fundamental concept in project management that refers to the longest sequence of tasks in a project, which determines the shortest possible time required to complete the entire project.
- APR1400 has a Critical Path for various Activities. In order to check the main Activities by CP, this study first classified the most important Critical by Type.

Table 1. Critical path activities for the RCB by work type

Type	Main Critical Path Activities
Civil	Power Block Excavation, Mudmat Concrete, Water Proofing/Protect Concrete, FR&P Basemat, FR&P Liner Cover Fill Slab, FR&P IRWST, FR&P Exterior Wall, FR&P. Shield Wall, FR&P Dome
Strucural Steel	Basemat Liner Plate, Wall Liner, Erect IRWST SSLP, Install Girders & Rails, Erect Dome Liner, Install & Tension Tendons, Install Pipe Whip Restraints
Mechanical	Install NSSS Equipment(RCV, RC, etc), Erect & Test Polar Crane
Piping	Install RCS L/B Pipe & Support before and after RV
Electrical	Cathodic Protection

Results

3.1 Critical Path by Construction Package

- Table. 2 presents the Critical Paths corresponding to the CPs in APR1400. A total of five Construction Packages include activities on the Critical Path: C1, A1, M1, M3 and P1.

Table 2. Activities and Critical Paths by CPs

PKG No.	Package	Activities	C.P
CP-C1	Foundation Excavation	Power Block Excavation, RCB Mudmat Concrete, FR&P Basemat	O
CP-C2	Concrete Production Work	Plant Concrete Facilities & Production	
CP-C3	Outdoor Underground Installation	Yard Work (Yard Area Install Equip./Insulation/Misc.)	
CP-C4	Cooling Water System	Cooling Water Structure Work	
CP-Y1	Underwater Drainage Structure	Yard Work (Drainage, Wastewater Facilities)	
CP-A1	Construction of Main Building	FR&P Basemat, Wall, Dome, Strucural Steel	O
CP-M1	General Equipment Installation	Install Mech. Equipment Wall Liner, Sump Liner, Dome Liner	O
CP-M2	Condenser Installation Work	Re-Fabrication and Erect Condenser	
CP-M3	Turbine Generator Installation	Install Turbine Components	O
CP-M5	Nuclear Steam Supply System(NSSS) Installation	Install RC Pump Internals & Motor Set Reactor Vessel RPV Internals Installation	(O)
CP-M6	On-Site Assembly Tank Installation	Yard Tanks Installation	
CP-P1	Piping Installation	Install Embedded Pipe Install L/B, S/B Pipe & Support	O
CP-P2	Insulation Work	Pipe Insulation	
CP-E1	Electrical Equipment Installation	Install Cable Tray & Support, Install Misc. Elect. Equipment, Conduit, Cabling & Termination	(O)
CP-E2	Cable Laying and Wiring Work		
CP-E3	Outdoor Switchyard Installation		
CP-E4	Instrumentation and Control (I&C)	Install I&C Equipment	

3.2 Modular items by Construction Package

3.2.1 CP-A1: Steel Plate Concrete

- The A1 Package includes the highest number of Critical Path activities in the APR1400 construction process. Steel-Plate Concrete (SC) replaced some structural elements due to its compatibility with modular construction [2].

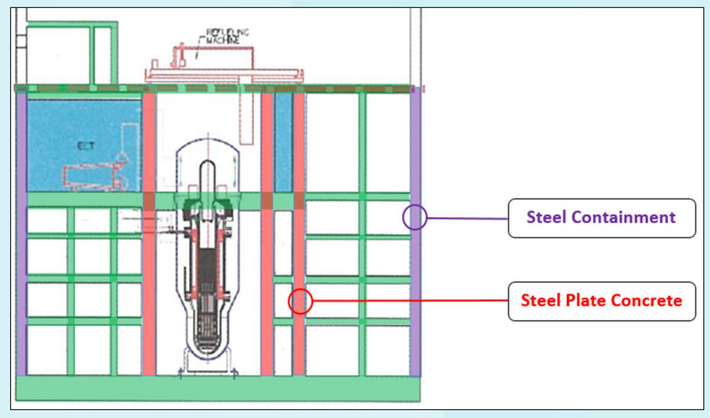


Fig. 1. Potential application range of SC in i-SMR

3.2.2 CP-A1, M1: Steel Modular

- The A1 and M1 Packages encompass steel structures and Stainless Steel Liner Plate (SSLP) work along the Critical Path. Steel modularization refers to the process of transforming conventional steel structures into modular components, which can be prefabricated off-site and subsequently assembled on-site.

3.2.3 CP-M1, P1, E: MEP Module

- Pre-assembled components reduce on-site work, resulting in time savings compared to the original schedule [6]. Over the past decade, the modular prefabrication of mechanical, electrical, and plumbing (MEP) systems has become increasingly prevalent, driven by the growth of the prefabricated construction industry [7].

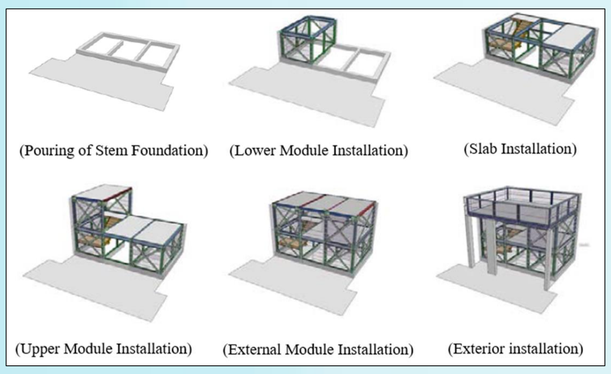


Fig. 2. Modular rooftop construction sequence [4]

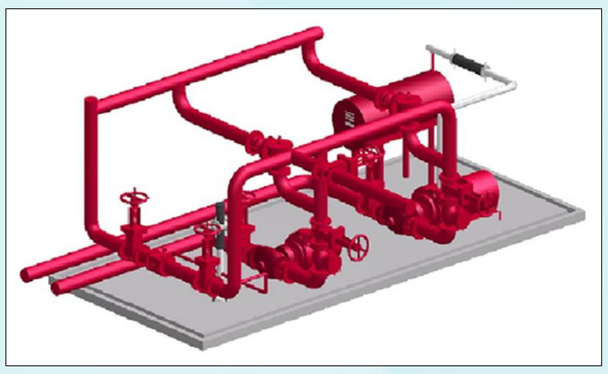


Fig. 3. MEP module for the firefighting system [7]

Conclusions

This study identifies the most effective work types and modularization strategies for shortening the construction period of i-SMR by correlating the CPs of the APR1400 with its Critical Path activities.

- ✓ First, the period for concrete work can be reduced by applying SC in CP-A1. This approach is the most effective method to shorten the construction period, as CP-A1 includes the most critical path activities.
- ✓ Second, Steel Modularization can be applied in the CP-A1, M1 to reduce the manufacturing and installation time for steel structures and SSLP.
- ✓ Third, the construction period can be further shortened by introducing the MEP module in the CP-M1, P1, E. Given the close relationship between the mechanical-piping-electrical connection process and the overall construction completion period in SMRs, the impact of modularizing this process is expected to be highly significant.

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