

# Methods of Reviewing Constructability of Nuclear Power Plants Utilizing a Data-based Technology

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**Abstract:** A nuclear power plant construction project normally involves a large construction work of which the total project cost is over 5 trillion Won. Such a large-scale construction project has the risks of schedule delay and quality degradation due to increase in project cost, because designs are changed due to design errors. The reasons for design changes during installation are 1) insufficient engineering capability of the owner, 2) information discontinuance due to the multiple package method, and 3) inefficient constructability review processes. Accordingly, this study proposes, through problem analysis, a method of developing a constructability review system that utilizes constructability review processes and a data-based technology (3D modeling) that are optimized for nuclear power plant construction projects. It also presents a method of establishing a system for reviewing constructability in which constructability review processes and a Database (3D model, Schedule, Design change Items) are linked each other.

**Keywords:** Nuclear Power Plant, Constructability, 3D model, Schedule, Design change Items

## I. INTRODUCTION

A nuclear power plant construction project normally involves a large construction work of which the total project cost is over 5 trillion Won. Such a large-scale construction project has the risks of schedule delay and quality degradation due to increase in project cost, because an average of 2,000 to 3,000 design changes is made. Items of design changes relating to nuclear power plant construction can be categorized into field change requests (FCR), vendor field change requests, and start-up filed change requests by stage; and into construction, civil engineering, machinery, piping, electricity, and instruments by area. This study derives types and results of design change occurrences through analyzing design change cases relating to domestic nuclear power plant construction projects based on the occurrences of FCR, and proposes a method of applying a program for reviewing constructability that utilizes a data-based technology.

## II. OVERVIEW OF CONSTRUCTION OF DOMESTIC NUCLEAR POWER PLANTS

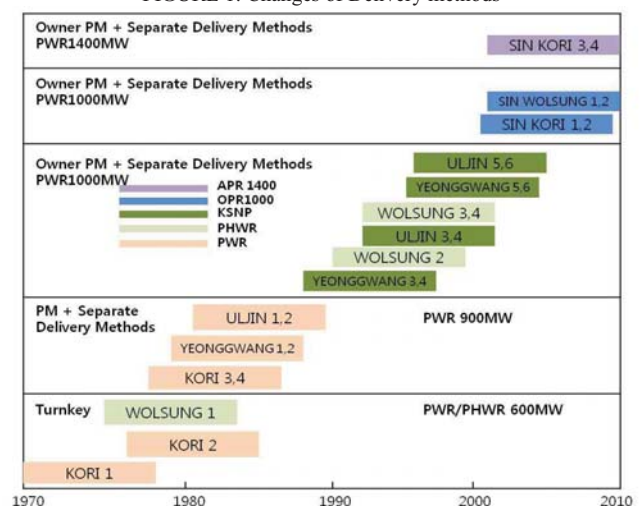
For a domestic nuclear power plant construction project, contractual relationship is made centering around an EPC contractor, while overall designing, major devices (NSSS), T/G and nuclear fuel suppliers have established an exclusive supply and cooperation mechanism in consideration of the uniqueness of nuclear power plants. Meanwhile, in the domestic nuclear power plant construction projects, ordering in the form of multiple packages, operation in the type of fast tracks, information discontinuance and lack of collaboration between designing companies and construction companies by

contract timing limit information sharing among all the stakeholders in the planning stage, which is problematic. In addition, as the design review processes of the owner organization are limited to regulatory requirements, design requirements, and technical review, they do not indicate a specific method of review of constructability.

### 2.1 Analysis of Ordering Methods of Nuclear Power Plant Construction Projects

The Korean Hydro and Nuclear Power Co., Ltd., (KHNP) has been ordered to Nuclear Power Plant Project over the last 40 years.

FIGURE 1. Changes of Delivery methods



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TABLE I.

Category	Sub-category	Handling Result
D00_Design Defects	D01_Non-commercial material	- Material change (spec/material)
	D02_Structural Defects	- Drawing change (expression change)
	D03_Functional Defects	- Not implemented
	D04_Unnecessary Work	- Interference with the previous activity
	D05_Drawing Errors	- Change of design standard strength
	D06_Construction Guidance Errors	- Improvement/change of construction method
F00_Securing of Constructability	F01_Construction Space Interference	- Material change (spec/material)
	F02_Construction Convenience	- Guidance change
	F03_Activity Interference	- Re-design
	F04_Constructability Problems	- Additional work
	F05_Constructability Improvement	
	F06_Securing of Construction Safety	
C00_Construction Errors	C01_Functional Defects	

Delivery method has been replaced by the time periods. It was changed to the current separate delivery method form Turnkey delivery methods. The general project management of KHNP that is carried out in the design stage of domestic nuclear power plant construction projects focuses on quality and safety, while the Korea Power Engineering Company, Inc. (KPEC), which is a general design service company, implement the work under the support of project management. Therefore, the number of the roles of the KHNP is rather small in terms of purchase, procurement, and installation. As the domestic nuclear power plant construction projects are operated in the fast track method that increases the level of perfection of the design during the construction process, while the main facilities works are launched with the designs not completed, review of constructability in the design stage is somewhat limited.

## 2.2. Analysis of Constructability Review Processes

According to review of the design documents/drawings and approval procedures under the current standard project management procedures for nuclear power plant construction, the major review items of the procedures are divided into items relating to technical review including review of design engineering information among the items of the design documents/drawings check list, regulatory requirements such as certification/permission requirements and criteria, and items relating to design requirements. However, in terms of specific review items, constructability review process is not established because specific review items are not indicated. In addition, there is a problem of limitation due to review of design documents/drawings which are not managed as data, and insufficient capability of reviewers. Consequently, it is needed to adopt a process that utilizes design/installation experts based on a technology which is managed with data.

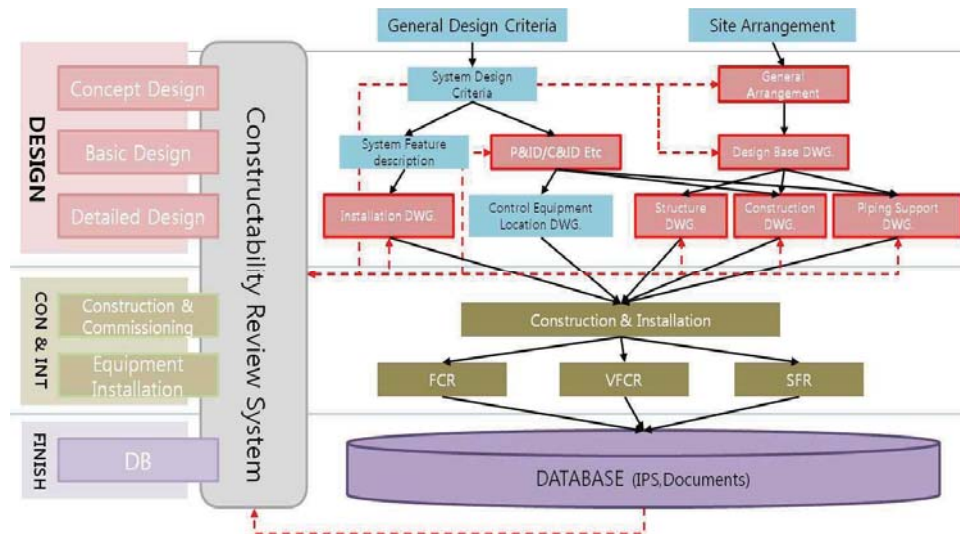
## 2.3 Analysis of Design Change Items

Based on an analysis of the FCR of the domestic nuclear power plant construction projects, the types and results of the occurrences of design changes have been derived. The types are categorized into the 3 areas of D00\_Design Defects, F00\_Securing of Constructability, and C00\_Installation Errors. D00\_Design Defects relate to the areas which should have undergone review in the design documents/drawings and instruction in terms of errors of design drawings and instructions, as well as structural/functional defects, which may lead to adverse results including partial re-designing or drawing changes. F00\_Securing of Constructability can be divided into the positive aspect of the improvement in construction convenience and constructability, and the negative aspect of space/activity interference, and problems in constructability. This may lead to positive results such as shortened schedule, cost saving, and improvement of construction methods, as well as negative results such as changes in materials/construction methods, and additional work. C00\_Installation Errors relate to forecast or occurrence of functional defects before or after construction and installation. They may lead to negative results such as delay of schedule or cost increase, because such errors necessitate re-designing or re-work. The average handling period of a design change is 3 to 7 days, but it may sometimes takes over a month. A design change is likely to play a role of a hazard in the nuclear power plant construction project management. Therefore, minimization of design changes may decide success or failure of the nuclear power plant construction project management.

### III. A MODEL ADOPTED BY THE PROGRAM FOR REVIEWING CONSTRUCTABILITY OF NUCLEAR POWER PLANTS

An existing study of "A Study on a Basic Model for Adopting a Constructability Program for Korea-type

FIGURE 2. Configuration of constructability review system



Nuclear Power Plants" (Lim Byung Ki, et. al.) presented a phased basic model for adopting a constructability program for nuclear power plants having 4 stages (project planning stage, design stage, implementation stage, and finish stage). However, this study further divides the stages presented in the above study, and presents a constructability program which is categorized into concept design, basic design, detailed design, construction and commissioning, equipment installation and finish. The detailed constructability review processes of nuclear power plants automates information on D00\_Design Defects, F00\_Securing of Constructability, and C00\_Construction Errors through linking a data-based model (3D Model), and construction activities; and provide the information to the owner, and the reviewers.

### 3.1 Proposed Constructability Review Processes and System for Nuclear Power Plants

For the constructability review processes, this study selected control points of the processes in the design stage where review of constructability is possible, and proposes constructability review processes in linkage with a constructability review system. This study proposes automated constructability review processes in which the existing design change items are linked with the IPS(Integrated Project Schedule) level, and in which design data (3D) generated at each control point are linked with a constructability review system.

Based on the result (Table 1) of the analysis of the FCRs of the domestic nuclear power plant construction projects, this study proposes a constructability review system in which FCRs by sub-category (D01 - C01) are linked with nuclear power plant construction Schedule(IPS) and design data (3D model/drawing numbers).

## IV. CONCLUSION

This study proposes a method of establishing a constructability review System for nuclear power plants. It selects constructability review control points in the nuclear power plant design stage, and presents constructability review processes linked with the constructability review system. This study categorizes design change items based on the existing nuclear power plant design change data for the constructability review system, and proposes a development method that links nuclear power plant IPS processes and design data (3D model/drawings) based on the categorized design change items. In the future, the constructability review System that links the constructability review Process and Database(3D model, Schedule, Design change Items) may reduce occurrences of nuclear power plant design changes and the re-work ratio, and may eventually minimize schedule delays and cost increases.

## ACKNOWLEDGMENT

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