A Study on the Constructability of Steel Plate Concrete Structure for Nuclear Power Plant

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1. Introduction

Steel Plate Concrete(SC) structure has been proposed as a feasible alternative to the conventional Reinforced Concrete(RC) structure for the modular construction. Diverse construction techniques have been studied to shorten the construction period of Nuclear Power Plant(NPP). The application of SC structure for modularization of the nuclear power plant has considered as one of the most viable alternatives among the current construction methods to reduce construction duration. This paper introduces the review result of constructability regarding the application of SC structure for the nuclear power plant by exemplifying a construction plan based on an existing conceptual SC structure design for a building structure of an actual nuclear power plant, APR1400.

2. Constructability Review

Internal Structure of Reactor Containment Building in APR1400 has been studied for the application of SC structure prior to its overall application to the nuclear power plant buildings. Internal Structures originally consist of RC and Steel structures which contain reactor vessel, and also support and protect NSSS. SC structures replace the original RC structures: Secondary Shield Wall including Steam Generator Shield Wall, Refueling Pool Wall and In-containment Refueling Water Storage Tank.

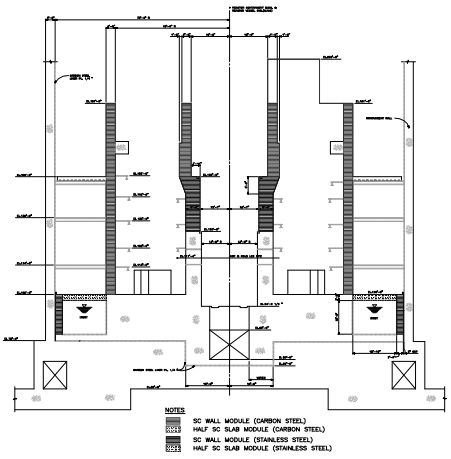

Fig.1 Application of SC structure for RCB Internal Structures of APR1400

SC structure application is carefully analyzed in the field of procurement, fabrication, transportation, erection, and construction schedule. Changes of dimension are not considered in this study

2.1 Procurement

Large amount of on-site processes are transferred to off-site shop fabrication by application of SC structure. In addition, there is a big change in the quantity of each procurement item. In comparison with RC structure, the amount of reinforcing bars, forms, and their supports decreases dramatically. On the other hand, the amount of steel plates and studs increases. Some new material such as duplex stainless steel is added to the procurement list.

Item	Unit	RC (A)	SC (B)	Difference (B-A)
Concrete	CY	9,606	9,606	-
Form(Flat)	SF	45,731	-	- 45,731
Form(Curved)	SF	46,924	-	- 46,924
Rebar(#3~#11)	MT	839	82	- 757
Rebar(#14~#18)	MT	1,566	40	- 1,525
SSLP	MT	225	4	- 221
Half SC SSLP	MT	-	167	+ 167
Half SC CLP	MT	-	98	+ 98
SS Module	MT	-	640	+ 640
CS Module	MT	-	1,401	+ 1,401

Table 1. Quantity Comparison of SC structure with RC structure

This shows that a conventional procurement system can deal with the SC structure application in Internal Structure without a crucial change, since a SC structure module is mostly composed of unparticular items. Nevertheless, the time of purchasing should be carefully considered. Further study is required for the application of integrated modules which consist of various components or systems.

2.2 Fabrication

Review of SC structure module fabrication shows that it has many features, very similar to fabrication trait of steel liner plate for the reactor containment wall.

Class	Feature	Liner Plate Fabrication	SC module Fabrication
Material	Major Components	Plate, L-shape angle	Steel Plate, Stud, Rib
Module Fabrication	Size	2.5m x 7.8m	3.2m x 6m
	Plate Cutting	Plasma, Gas cutting	Plasma, Gas cutting
	Junction	Welding	Welding
Module Assembly	Junction	Welding	Welding, Bolting
	Welding	GTAW+FCAW	GTAW+FCAW

Table 2. Comparison SC structure with Steel liner plate for fabrication features

2.3 Transportation

SC structure module can be classified as small-scale module, medium-scale module, large-scale module by its size. Small-scale module weighs approximately 22ton and its size is about 19'x10'x3'. Medium-scale module is an assembled module by a layer or a floor. Large-scale module consists of more than 2 medium-scale module. Medium and large-scale module have a benefit to save the on-site assembly time, but they are not recommended for the normal NPP construction project because there are limits in transportation method by national laws or regulations. Small-scale module to be transferred by ground or by marine and to be assembled on-site is appropriate for ordinary NPP construction project.

2.4 Erection

Arrangement of the on-site assembly shop, capacity of the lifting equipment and scheduling the lifting process affect the erection process. The size and location of assembly shop affects the size and shape of the assembled module and it may require additional on-site transportation. Over-the-top construction method is highly recommended for medium-scale module which weights about 520ton. A heavy-duty crane such as Lampson LTL-2600 and LR11350 crawler crane is considered as an appropriate lifting device. Parallel method – to lift SC module during Containment Liner Plate fabrication – is feasible to avoid lifting interferences because SC module erection could be completed before the settlement of polar crane bracket at the top of the wall liner plate. By modularization, simplified work sequence is expected to enable the erection process highly constructible. The division plan of SC module –vertical or horizontal– shall be decided by the selection of erection method.

2.5 Construction Schedule

Schedule alterations in procurement, fabrication, and erection from the adoption of SC structure module are evaluated. Time evaluation of each activity is based on an actual construction schedule of OPR1000, equivalent to the plan schedule of the current APR1400 which has symmetrically similar geometric shape with that of OPR1000. 11 month period from the signature of the purchase contract to the first SC structural module is assessed to be practical in comparison with the structural steel and Containment Liner Plate. It is anticipated to take less than 24months from procurement to the delivery of SC module to site.

Construction schedule for Primary Shield Wall, Refueling Pool Wall & its support wall, Secondary Shield Wall and In-containment Refueling Water Storage Tank structure of SC structure is analyzed to evaluate influence of SC module application. The SC structure modularization is expected to shorten the construction period by 3 month by means of the change of Secondary Shield Wall from 10.5 months to 5.5 months(only 3 months is reduced on the critical path). The reduction of construction period for In-containment Refueling Water Storage Tank and other Structures are disregarded since they are not on the critical path.

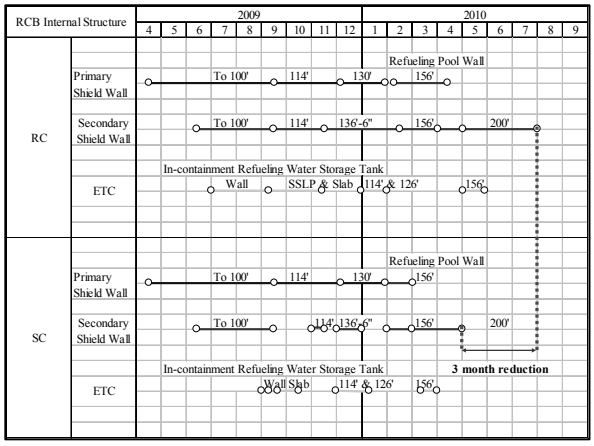

Fig.2 Schedule Comparison SC structure with RC structure

3. Conclusion

This study exemplifies that SC structure modular construction is not only feasible for the nuclear power plant construction but also an effective structural system to improve the constructability through whole construction stages by implementing prefabrication, preassembly and modularization. Furthermore, its application for the nuclear facility is expected to reduce the construction period and to improve the structural quality and working environment innovatively.

Acknowledgement

The research reported in this paper was made possible by the financial support from Electric Power Infrastructure Fund of Ministry of Knowledge Economy. The authors would like to express our gratitude to this organization for the financial support.

REFERENCES

[1] 2nd annual report for Development of Modular construction in NPP research project, 2007

[2] "Feasibility Study on the Modularization of Structure and System Facility for the Nuclear Power Plants", Korea Hydro & Nuclear Power Co. Ltd 2002.3

[3] Modularization Design Technique Evaluation, Next Generation Reactor Technique Development(I), Reactor Type Assessment Technique, vol8, Korea Electric Power Research Institute, 2004

[4] Christopher W. Lapp and Michael W. Golay, "Modular design and construction techniques for nuclear power plants", Nuclear Engineering and Design, pp.327-349, 1997