A study of fabrications of Steel Plate Concrete(SC) modular systems for nuclear power plants

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1. Introduction

Modularization has been proposed as a nuclear power plant design-construction approach for increasing the quality and reducing the costs of future plants. The modules based on the Steel Plate Concrete (SC) structures are well known construction techniques in ship, building, and plant construction over the world. They are expected to be feasible to obtain an alternative to the conventional reinforced concrete structural system to solve the limitations of modularization and to expand modules to large scales.

Studies are performed on overall aspects of fabrications i.e. on appropriate selection of materials and proper methods of welding, coating and assembly. This paper mainly introduces design techniques for fabrications of unit modules considering convenience in assembling, simple welding and proper arrangement of elements for further connections of unit modules and intermediate modules considering appropriate connections, heights of concrete placement and transportable capacities of cranes.

2. Materials, Welding and Coating

Carbon-steel would be used to most of SC structural steel of nuclear power plants including secondary shield wall and shield walls of pressurizer and steam generator. Carbon-steel of structural member should have high mechanical strength, appropriateness of welding, light weight considering lifting and low cost. 'KS D 3515 SM490' is recommended as a proper standard material of carbon-steel from studies on previously mentioned properties.

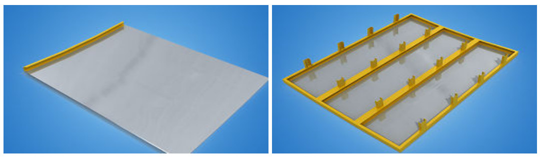
Stainless-steel of SC structural steel would occupy about 25~35% in SC structure of nuclear power plants. As stainless-steel of SC structure is supposed to be easily exposed to corrosive conditions, 'DSS STS329LD' is recommended as a proper standard material in this study

Welding technologies, especially in-situ, are very important factors to reduce construction period. Based on generally used welding methods of liner plates with carbon steel of PWR containment, SAW(Submerged Arc Welding) and FCAW(Flux Cored Arc Welding) are recommended to weld carbon-steel in factory and in-situ, respectively. In case of stainless-steel, GTAW(Gas Tungsten Arc Welding) is generally recommended, but other methods of welding are needed to be continuously investigated to replace GTAW, which processes welding at a relatively low pace.

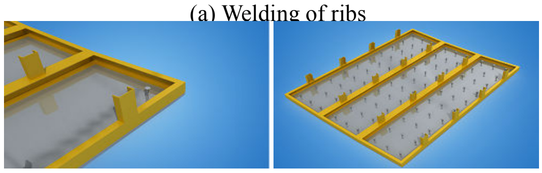
The coating of SC structural steel is performed according to general codes and procedures of nuclear power plants. Regulations of coating of SC structural modules are applied to only the parts of carbon steel exposed to air. Coating works are performed with inorganic zinc firstly, before completed with epoxy in the factory or site.

3. Fabrications of unit modules and intermediate modules

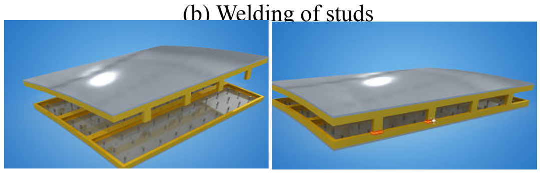
Unit SC modules are designed to be fabricated at a factory facility. Convenience in assembling, simple welding and proper arrangement of elements for further connections should be considered in fabrication of unit modules.



(a) Welding of ribs



(b) Welding of studs



(c) Welding between plates

Fig. 1 Procedures of unit module fabrications

The procedures of unit module fabrications are shown in Fig. 1 and could be summarized as follows.

· Step1: H-type ribs and C-type ribs are welded at inner parts and edges of a plate, respectively and then C-type ribs are welded on pre-welded ribs to obtain desirable gaps between two plates and connect them.
· Step2: Studs are welded on a plate by welding machines using instantaneous high electric current.
· Step3: Two plates, that were fabricated seperately, are placed on an assemble table and combined by welding of C-type ribs between them.

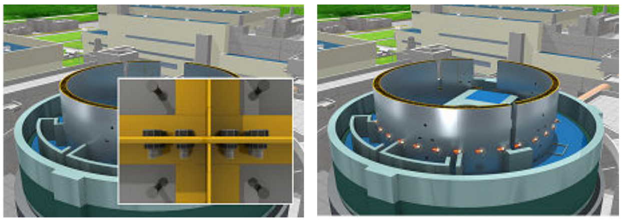
Appropriate sizes of unit modules are determined by transportation ways, handling abilities of lifting equipments, convenience in fabrication, heights of concrete placements and so on. And specific sizes of unit modules are controlled by sizes of structural members to which those modules are applied and consideration of connective continuities. For example, sizing of unit modules of a secondary shield wall of a containment building considering connectivity is explained as follows.

A secondary shield wall is a cylinder type wall with 56′-0″ height and 4′-0″ thickness. Intermediate modules, which are jointed with several unit modules in site, of secondary shield walls are consisted of three stories with 18′-3″, 18′-3″ and 19′-6″ height intermediate modules connected by more than 30 unit modules. Especially, intermediate modules of the first story are fabricated to 18′-3″ height by connections of unit modules with 14′-0″ and 4′-3″ height considering connectivity to the adjacent rooms of which slabs are supposed to be joined to secondary shield walls at 16′-0″ height.

Intermediate modules are to be fabricated considering proper connections, heights of concrete placement and transportable capacities of cranes.

Intermediate modules are fabricated at on-site fabrication facilities with horizontal connections of unit modules as shown in Fig. 2(a).

(a) Horizontal connections at on-site facilities



(b) Vertical connections at sites of structures

Fig. 2 Fabrications of intermediate modules

After completion of horizontal connections of unit modules at on-site facilities, intermediate modules are shifted to installation sites of structures by lifting equipments like crawler cranes or ringer cranes.

Vertical connections of intermediate modules shifted to installation sites should be considered to minimize deformations of steel plates due to welding and to guarantee convenience of works for reduction of construction period.

Accordingly, intermediate modules are proposed to be connected vertically by bolting of C-type steel ribs before welding of plates as shown in Fig. 2(b). Placements of modules and confinements by bolting are expected to guarantee accuracy of connections minimizing construction errors and to reduce duration time of welding.

Vertical connections are followed after completion of concrete placement of previous stories at each step. The heights of concrete placement are needed to be controlled to prevent strength degradations and damages of concrete due to heat with considering heat affected zone by welding. As a result of the study, it is recommended to keep heights of concrete placement 30~40cm below from edges of intermediate modules of the following story.

In addition, transportable capacities of cranes should be checked. Since a crane having capacity of lifting a steam generator (791ton) is supposed to be used, the crane has sufficient capacity to lift and move intermediate modules of which the maximum weight is evaluated to be about 520ton by this study.

4. Conclusions

The studies are performed on overall aspects of fabrications i.e. selection of appropriate materials, proper methods of welding, coating, and assembly. Especially, the procedures of unit module fabrications considering proper connections, convenience in assembling and simple welding and the procedures of intermediate modules considering proper connections, heights of concrete placement and transportable capacities of cranes are mainly proposed in this paper, which give useful and applicable results in fabrications of modules in view of considered points.

Acknowledgement

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