Damping Ratio of SC Structure

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Abstract

The purpose of this technical report is to present the damping ratio of SC structure of the US-APWR standard plant.

This report describes:

- Descriptions of 1/10-scale-model Test of Inner Concrete Structure
- Comparison of the typical dimensions between US-APWR and Scale-model
- Evaluation of Damping Ratio

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List of Acronyms

The following list defines the acronyms used in this document.

APWR	**Advanced Pressurized Water Reactor**
FEM	**finite element method**
I/C	**inner concrete**
JIS	**Japanese Industrial Standards**
MHI	**Mitsubishi Heavy Industries, Ltd.**
MW	**mega watt**
NRC	**Nuclear Regulatory Commission**
PCCV	**prestressed concrete containment vessel**
PWR	**Pressurized Water Reactor**
RV	**reactor vessel**
R	**relative rotation angle**
R&D	**Research and development**
SC	**Steel concrete**
SG	**steam generator**
US, U.S.	**United States**

1.0 INTRODUCTION

This report shows study and evaluation of the damping ratio used for dynamic response analysis of US-APWR I/C using the SC modules, based on the experimental results.

Data on damping ratio of SC structure has been obtained by 1/10 model test performed by Mitsubishi Heavy Industries, LTD. However the model used in the test was designed to simulate configuration of I/C structure adopted in Japanese 1000 MW power plant at that time. There is a slight difference between configurations of I/C structures of the model and US-APWR.

To evaluate the adequacy to adopt the damping ratio obtained by the experiment for US-APWR I/C structure, comparison of the both structures for dimension has been performed. Based on the comparison it was concluded that the damping ratio of the SC structure obtained by the experiment can be applied to US-APWR I/C structure.

2.0 DESCRIPTIONS OF 1/10-SCALE-MODEL TEST OF INNER CONCRETE STRUCTURE COMPOSED OF CONCRETE FILLED STEEL BEARING WALL (SC STRUCTURE)

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3.0 COMPARISON OF THE TYPICAL DIMENSIONS

Table 3-1 shows comparison of the typical dimensions of SC I/C structures adopted in the 1/10-scale-model and US-APWR. Figure 3-1 to 3-2 show the plans and sections of SC I/C structures of both US-APWR and 1/10-scale-model.

Table 3-1 Comparison of dimensions

	Component	Symbol	US-APWR(a) (mm)	1/10 model(b) (mm)	Ratio(a/b)
Comparison to dimension and thickness of plan	Primary Shield Wall	X1	12548	1130	11.1
		Y1	12065	1080	11.2
	Refueling Canal Wall	X2	15697	1390	11.3
		Y2	11735	1080	10.9
	Pressurizer Wall	X3	6833	850	8.0
		Y3	8992	840	10.7
	Secondary Shield Wall	X4	28194	2400	11.7
		Y4	29921	3760	8.0
	SG Wall	X5	19588	1700	11.5
		Y5	9322	891.4	10.5

The comparison in the above table shows that the dimensions of US-APWR slightly exceed the basic scale ratio of 10 for the dimensions of scale-model adopted in the experiment, except dimensions of Secondary Shield Wall and Pressurizer Wall. However the difference or excess from the basic ratio are small. Basically it is thought that the typical dimensions of US-APWR are approximately 10 times to those of 1/10-scale-model.

It is concluded that the typical dimensions of US-APWR are approximately 10 times to those of 1/10-scale-model and the experimental result of the scale model can be applied to the SC I/C structure of the US-APWR.

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Figure 3-1 Plan of US-APWR I/C SC modules

Figure 3-2 Plan of 1/10 model SC modules

4.0 EVALUATION OF DAMPING RATIO

As evaluated in Sec. 3, the damping ratio that has been assured by the experiment described in Sec.2 can be applied to SC I/C structure.

Summary of the 1/10 model test has been also reported at SMiRT10 Conference[*1].
In the report there are descriptions on the damping ratio of the SC structure obtained by the experiment that;

The hysteresis characteristics of SC structure have a spindle-shape like steel structure and show a good behavior.

In the tested SC structure, the equivalent damping ratio was about five percent before the steel yielded while it increased dramatically after the steel yielded.

Which means that as the experimental results, for loads within the design values, the equivalent damping ratio determined from the load-displacement curve loop is about 5% for SC structure. SC structure maintains this ratio at about 5% until steel plates yielded. After yielding, damping gave way to a preponderance of hysteresis damping, resulting in a rapid increase in the equivalent damping ratio.

[*1]: 1/10th Scale Model Test of Inner Concrete Structure Composed of Concrete Filled Steel Bearing Wall, SMiRT10, pp73-78, 1989