Fukushima Daiichi Nuclear Power Station Unit No. 1
Report on earthquake response analysis of the reactor building, important equipment and piping system for earthquake-resistant safety using observed seismic data during the Tohoku-Taiheiyou-Oki Earthquake in the year 2011 (Summary)

1. Introduction

We collected an abundance of seismic data based on observations of the reactor building's base mat etcetera on March 11th, 2011, the day the Tohoku-Taiheiyou-Oki earthquake struck.

In accordance with the instruction document* from the Nuclear and Industrial Safety Agency (hereafter NISA), we conducted an earthquake response analysis using the observed seismic data of Unit 1 of Fukushima Daiichi Nuclear Power Station. Hence, we are reporting the results of the analysis of the reactor building, important equipment and the piping system for earthquake-resistant safety.

* Instruction document

"Actions following the analysis of seismic data collected at Fukushima Daiichi nuclear power station and Fukushima Daini nuclear power station during the Tohoku-Taiheiyou-Oki Earthquake (Instruction)" (NISA No.6, May 16, 2011)

2. Reactor building

We conducted an earthquake response analysis of Fukushima Daiichi Nuclear Power Station, Unit 1, utilizing the seismic data obtained from observations of the base mat with the objective of verifying the status of the building during the event.

The analysis used the proper building and ground models shown in Fig. 1.

As a result of the analysis, the maximum shear strain of the seismic wall was 0.14×10^{-3} (north-south direction, 1F), and the stress and strain were confirmed to be below the first knee point on the skeleton curve for all seismic wall, as shown in Fig. 2 and Fig. 3.

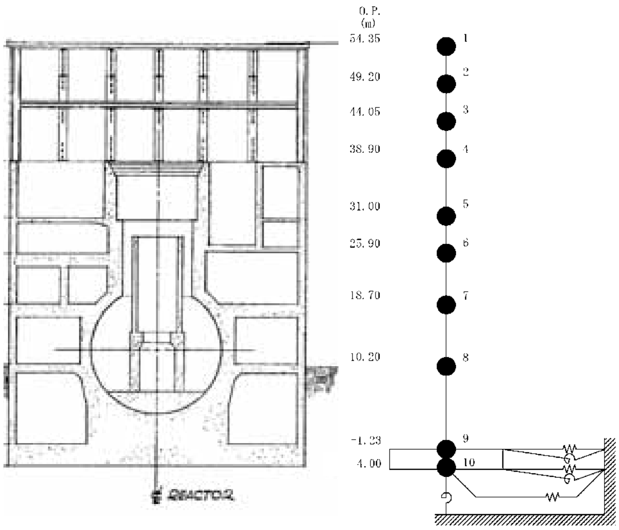


Fig. 1 Model of Unit 1 reactor building

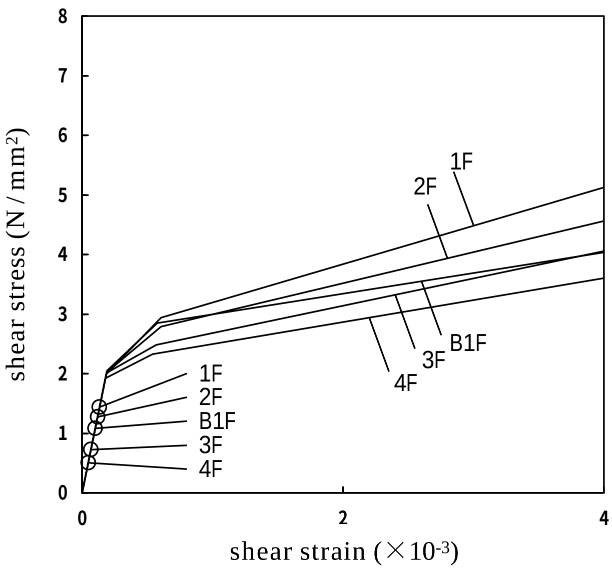


Fig. 2 Shear strain of seismic wall
(north-south direction)

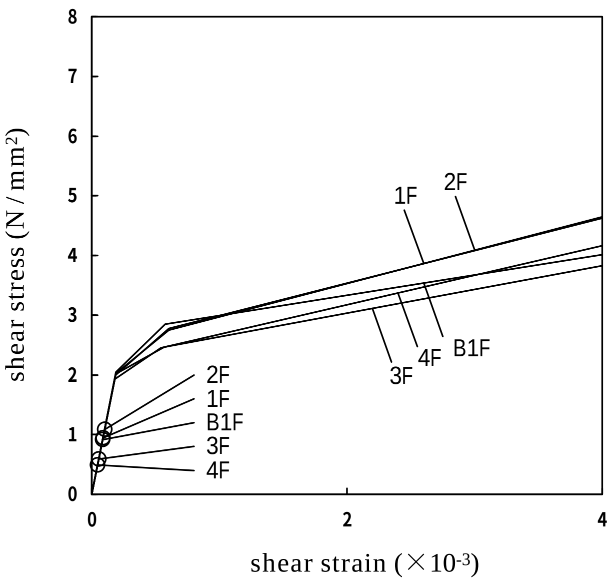


Fig. 3 Shear strain of seismic wall
(east-west direction)

3. Important equipment and piping system for earthquake-resistant safety

We analyzed the earthquake responses of the large-size equipment such as the nuclear reactor of Unit 1 utilizing the observed data obtained during the earthquake. The results were compared to the seismic load etc. provided by the seismic safety assessment using the defined design basis ground motion Ss.

It was found that some indexes such as the seismic load by the earthquake exceeded the ones from the seismic safety assessment. We performed a seismic assessment of the major equipment which plays an important role on safety operations relevant to the “Stop” and “Cool-down” operations of the nuclear reactor and the “Containment” of radioactive materials. As a result, it was confirmed that the calculated stress etcetera were below the results given by the assessment. (Table. 1)

Hence, it is presumed that the major equipment relating to safety operations are conditions that can maintain safety functions.

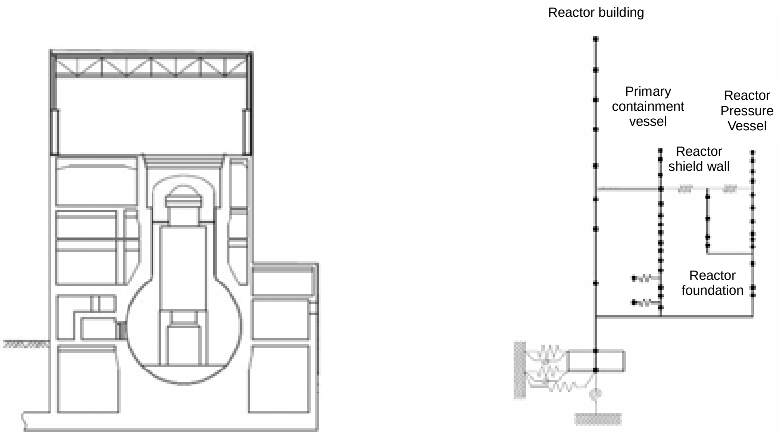
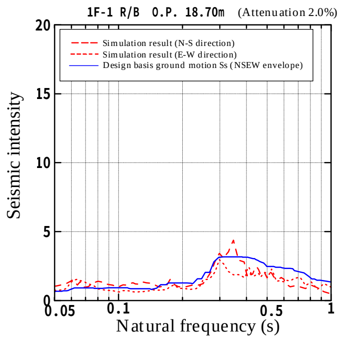
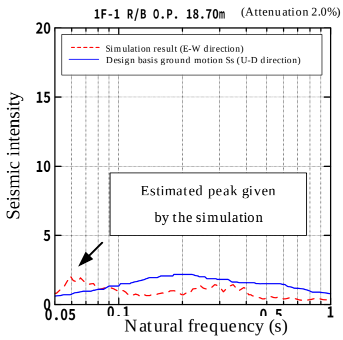
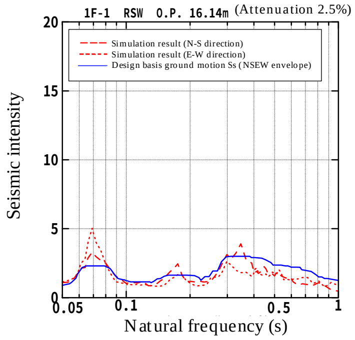
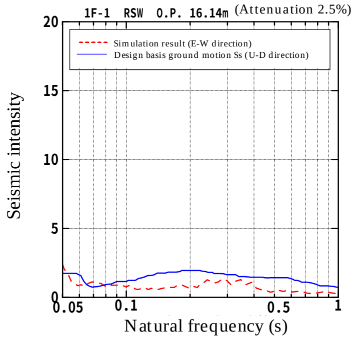


Fig. 4 Example of large equipment coupled earthquake response analysis

Table 1 Summary of the assessment of important equipment and the piping system for earthquake resistant safety (Fukushima Daiichi Nuclear Power Station, Unit 1)

Equipment		Earthquake response stress		design basis ground motion Ss	Simulation results	Results of seismic safety assessment
Seismic load and etc.	Reactor pressure vessel Base	Shear force	(kN)	4730	6110	Reactor pressure vessel (foundation bolt) Calculated result: 93MPa Criterion: 222Mpa
		Moment	(kN·m)	45900	62200	
		Axial force	(kN)	5250	3890	
	Primary containment vessel Base	Shear force	(kN)	4270	5080	Primary containment vessel (drywell) Calculated result: 98MPa Criterion: 411MPa
		Moment	(kN·m)	55900	64200	
		Axial force	(kN)	2070	1560	
	Core shroud Base	Shear force	(kN)	3060	3370	Core supporter (shroud supporter) Calculated result: 103MPa Criterion: 196MPa
		Moment	(kN·m)	15300	16600	
		Axial force	(kN)	1020	792	
	Fuel assembly	relative displacement	(mm)	21.2	26.4	Control rod(insertion) Criterion: 40.0mm
Seismic intensity	Fuel exchange floor	Intensity (horizontal)	(G)	0.96	1.29	Residual heat removal pump (motor mounting volt) Calculated result: 8MPa Criterion: 127Mpa
		Intensity (vertical.)	(G)	0.58	0.54	
	Base mat	Intensity (horizontal)	(G)	0.60	0.57	
		Intensity (vertical.)	(G)	0.51	0.32	
Floor response spectrum (reactor building)	< Middle layer (O.P.18.70m) >  (Horizontal)  (Vertical)					Main steam system pipe Calculated result: 269MPa Criterion: 374MPa Residual heat removal system pipe Calculated result: 228MPa Criterion: 414MPa

Floor response spectrum (reactor shield wall)	< Reactor shield wall base part (O.P.16.14m) >  (Horizontal)  (Vertical)	

Reference: Summary of seismic assessment (Example of Main steam system pipe)

Large equipment coupled earthquake response analysis

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Calculation of Floor response spectrum

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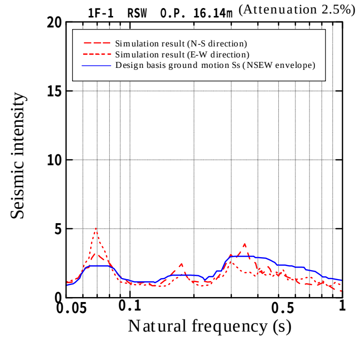
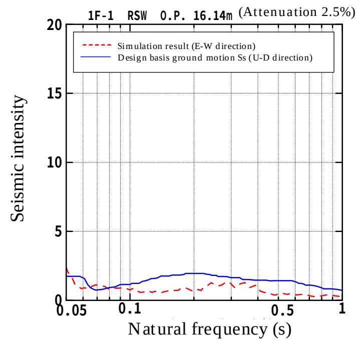
Evaluation of stress by spectrum modal analysis

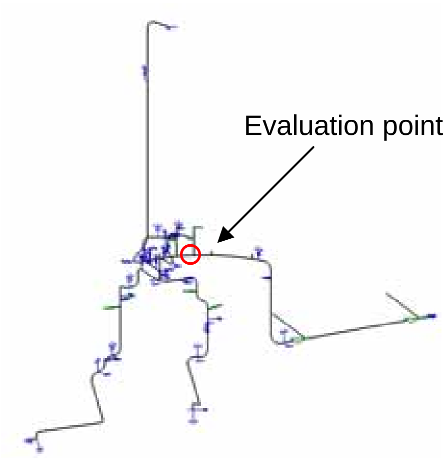
Flowchart of assessment





Floor response spectrum

Evaluation point for maximum stress



* Input signal into anchor and support (blue-color arrow in the figure)

Main steam system pipe

Results of the structural strength assessment

Equipment	Part	Design basis ground motion Ss				This earthquake			
		Stress	Calcu. (MPa)	Criteria (MPa)	Method	Stress	Calcu. (MPa)	Criteria (MPa)	Method
Main steam system pipe	Pipe	Primary	287*	374	Detail	Primary	269*	374	Detail

* It is considered that the calculated value of this earthquake became lower than that of design basis ground motion Ss because most part of floor response spectrum for vertical direction is lower than that of design basis ground motion Ss, although some part of floor response spectrum for horizontal direction is higher than that of design basis ground motion Ss

End