Fukushima Daiichi Nuclear Power Station Unit No. 4
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 4 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, March 16th, 2011)

2. Reactor building

We conducted an earthquake response analysis of Fukushima Daiichi Nuclear Power Station, Unit 4, 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 is 0.43×10^{-3} (east-west direction, 5F), and the stress and strain were confirmed to be below the first knee point on the skeleton curve excluding the east-west wall of 5F as shown in Fig. 2 and Fig. 3.

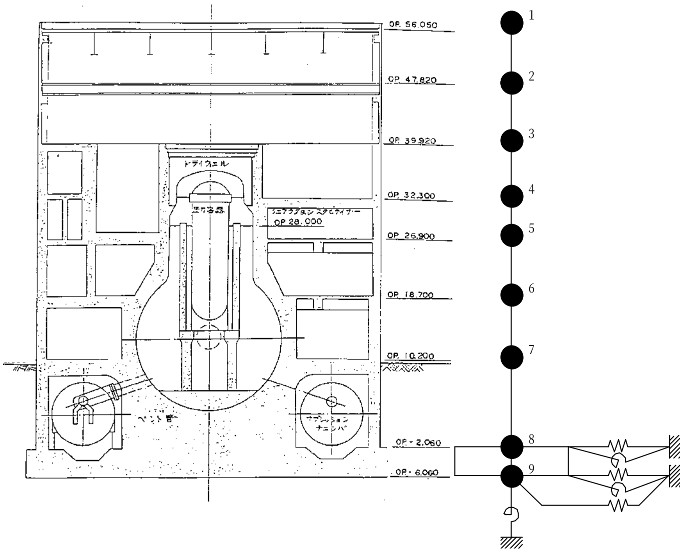


Fig. 1 Model of Unit 4 reactor building

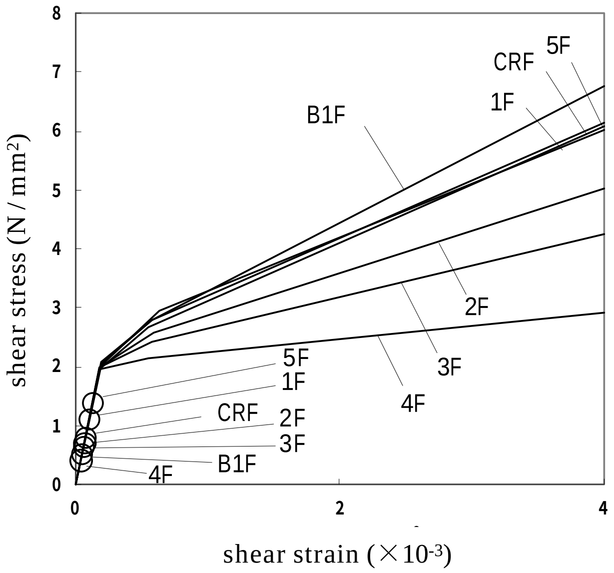


Fig. 2 Shear strain of seismic wall (south-north direction)

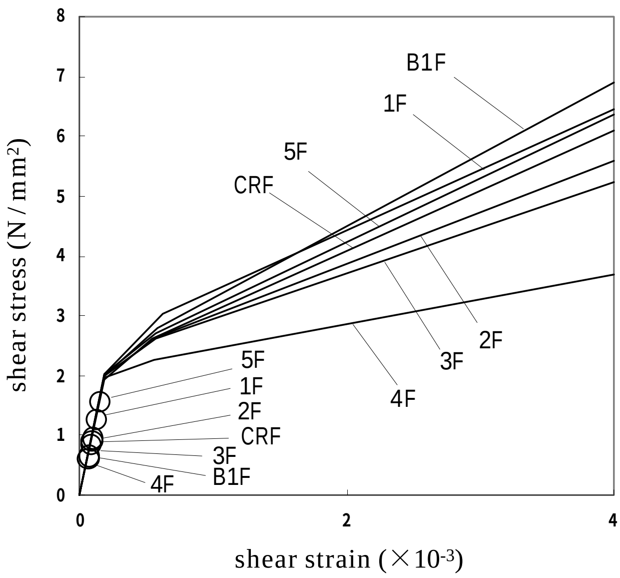


Fig. 3 Shear strain of seismic wall (east-west direction)

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 4 utilizing the observed data obtained during the earthquake. The results were compared to the seismic load etcetera provided by the seismic safety assessment using the defined design basis ground motion Ss.

It was found that the seismic load etcetera by the earthquake were below the ones from the seismic safety assessment excluding a peak portion of a floor response spectrum. It was confirmed that the calculated stress was below the results given by the assessment as well according to a seismic assessment result of the residual heat removal system.

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

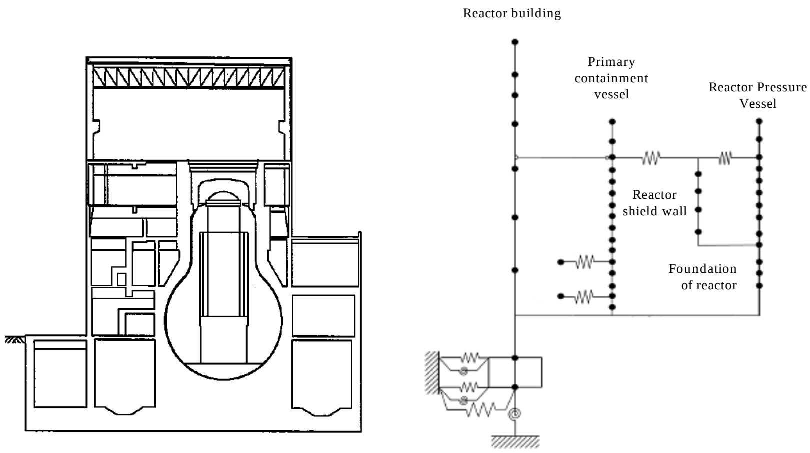
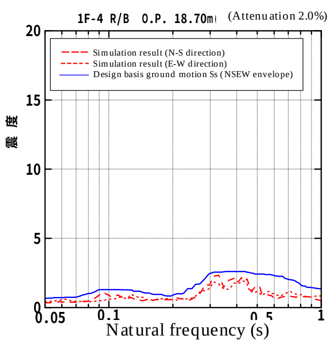
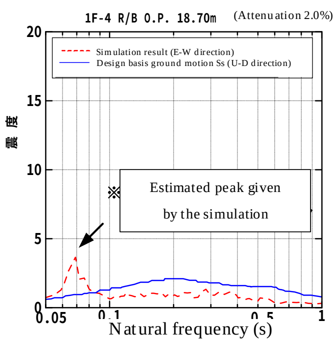
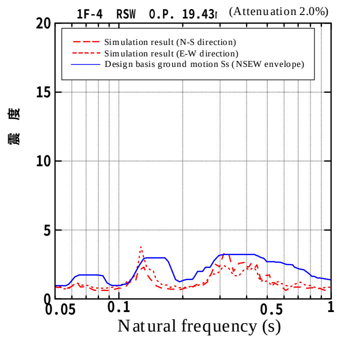
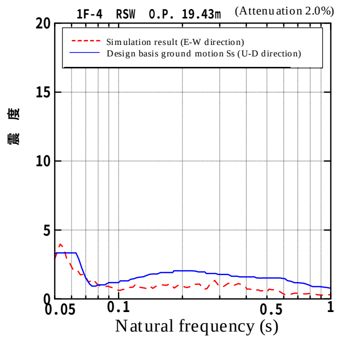


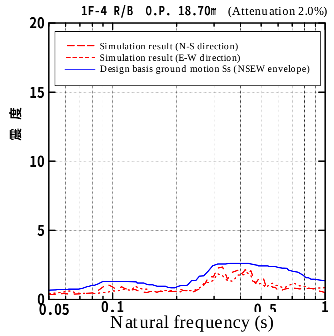
Fig. 4 Example of large equipment coupled earthquake response analysis model

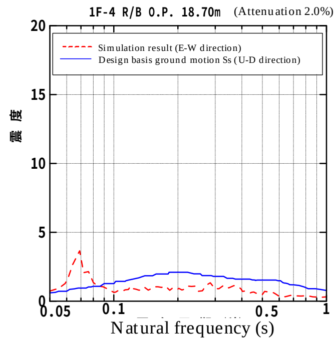
Table 1 Summary of the assessment of important equipment and the piping system for earthquake resistant safety (Fukushima Daiichi Nuclear Power Station, Unit 4)

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)	4790	4000	Reactor pressure vessel (foundation bolt) **N/A since the stress is below the result using Ss**
		Moment	(kN·m)	38900	28000	
		Axial force	(kN)	6660	6020	
	Primary containment vessel Base	Shear force	(kN)	6840	4910	Primary containment vessel (drywell) **N/A since the stress is below the result using Ss**
		Moment	(kN·m)	113000	79900	
		Axial force	(kN)	2460	1170	
	Core shroud Base	Shear force	(kN)	No shroud for replacement at the earthquake		—
		Moment	(kN·m)			
		Axial force	(kN)			
	Fuel assembly	relative displacement	(mm)	Fuel assembly was removed for regular inspection at the earthquake.		—
Seismic intensity	Fuel exchange floor	Intensity (horizontal)	(G)	0.96	0.68	Residual heat removal pump (foundation bolt) **N/A since the stress is below the result using Ss**
		Intensity (vertical.)	(G)	0.58	0.71	
	Base mat	Intensity (horizontal)	(G)	0.55	0.39	
		Intensity (vertical.)	(G)	0.52	0.25	
Floor response spectrum (reactor building)	< Middle layer (O.P.18.70m) >  (Horizontal)  (Vertical)					Main steam system pipe **N/A since it has been decoupled as a safety measure for the shroud replacement** Residual heat removal system pipe Calculated result:124MPa Criterion: 335MPa

床応答スペクトル（原子炉遮へい壁）	＜Middle of reactor shield wall (O.P.19.43m)>  (Horizontal)  (Vertical)	

Reference: Summary of seismic assessment (Example of residual heat removal system)





Floor response spectrum

Large equipment coupled earthquake response analysis

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Calculation of Floor response spectrum

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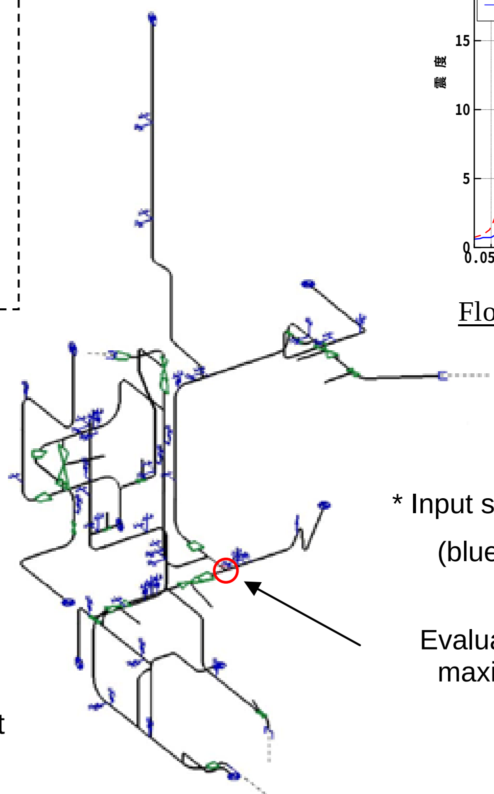
Evaluation of stress by spectrum modal analysis

Flowchart of assessment



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

Evaluation point for maximum stress

Model of residual heat removal 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
Residual heat removal system pipe	Pipe	Primary	137*	335*	Detail	Primary	124*	335*	Detail

* The comparison is a reference, since the evaluated part in the interim report was deactivated for a safety reason at the earthquake and this simulation uses the difference pipe model.

End