

Unit 1 of the Fukushima Dai-ichi Nuclear Power Station

Report related to the Results of the Seismic Response Analysis for the Reactor Building and for the Equipment and Piping Important to Seismic Safety using the Data Observed at the time of the 2011 Tohoku District – Off the Pacific Ocean Earthquake at Unit 1 of the Fukushima Dai-ichi Nuclear Power Station (Summary)

1. Introduction

A large volume of observed seismic data was obtained on the reactor building base mat and at other locations at the time of the Tohoku District – Off the Pacific Ocean Earthquake, which occurred on March 11, 2011.

Based on the directions (\*) sent by the Nuclear and Industrial Safety Agency (NISA), Tokyo Electric Power Co., Inc. (TEPCO) conducted a seismic response analysis using this observed data regarding Unit 1 of the Fukushima Dai-ichi Nuclear Power Station (NPS) and submitted a report to NISA summarizing the analysis results for the reactor building and for the equipment and piping important to seismic safety.

\*Directions

“Regarding the Action Based on the Results of the Analysis of Seismic Data Observed at Fukushima Dai-ichi and Dai-ni Nuclear Power Stations at the time of the 2011 Tohoku District – Off the Pacific Ocean Earthquake (Directions)” (05.18.2011 NA No.6)

2. Reactor Building

For the seismic response analysis of the reactor building of Unit 1 of the Fukushima Dai-ichi NPS at the time of the 2011 Tohoku District – Off the Pacific Ocean Earthquake, TEPCO conducted a seismic response analysis using the seismic data obtained on the reactor building base mat from the perspective of confirming the condition of the reactor building at the time of the earthquake.

TEPCO established a model (Fig. 1) in order to properly express the characteristics of the buildings, structures, and soil for the seismic response

analysis.

The results of the seismic response analysis verified that the shearing strain of the seismic walls was a maximum of  $0.14 \times 10^{-3}$  (north-south direction, 1F) and that the first bend in the skeleton curve for all the seismic walls showed the following stress and deformation (Figs. 2 and 3).

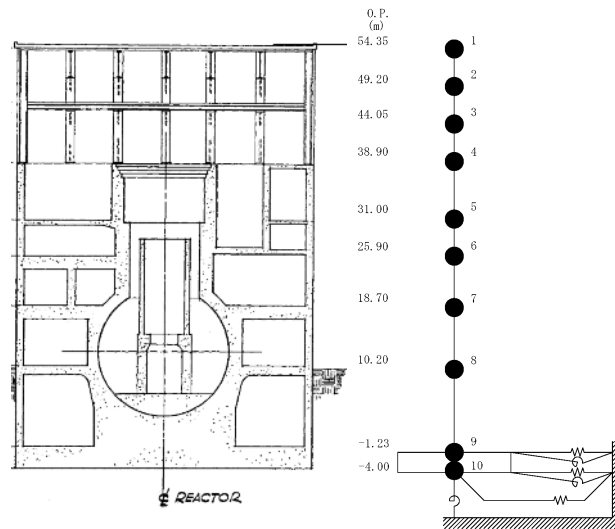


Fig.1 Reactor Building of Unit 1 (Model)

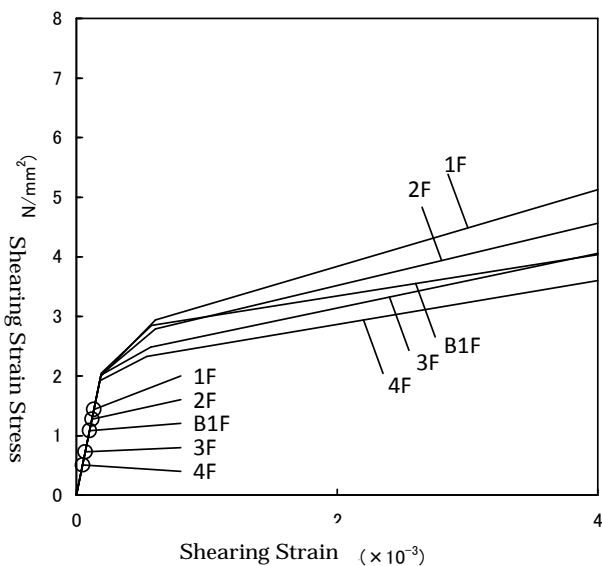


Fig-2 Shearing Strain of Seismic Walls (north-south direction)

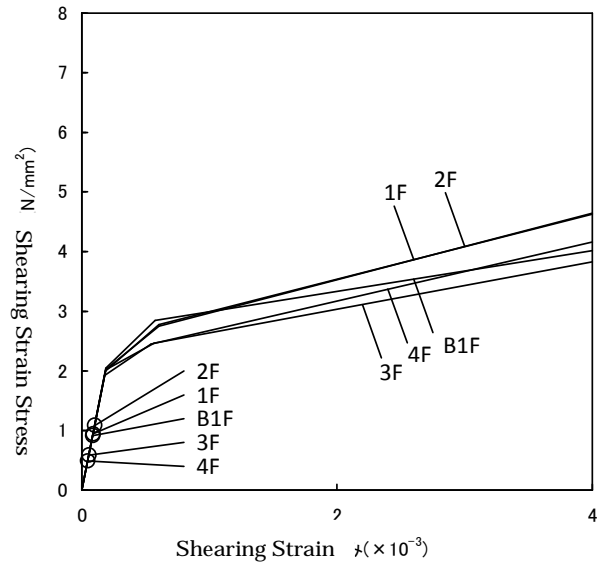


Fig-2 Shearing Strain of Seismic Walls (east-west direction)

### 3. Equipment and Piping Important to Seismic Safety

As to the large equipment, such as reactors, in the reactor building of Unit 1 of the Fukushima Dai-ichi NPS, TEPCO conducted a seismic

response analysis based on the data obtained at the time of the Tohoku District – Off the Pacific Ocean Earthquake as well as compared the seismic load, which was obtained from the seismic safety assessment conducted using the previous standard seismic motion  $S_s$ , with the seismic load obtained from the present results.

The results of the comparison showed that, although the seismic load by the March 11 earthquake partially superseded the seismic load obtained from the seismic safety assessment, TEPCO assessed the safety of the main facilities that have the important safety functions related to “shutting down” and “cooling down” the reactor, and “sealing off” the radioactive materials. Furthermore, the results of the comparison showed the following for the assessment standard values of the calculated stress and other characteristics (Table 1). It can be presumed from these results that the main facilities that have important safety functions are in a condition capable of maintaining the safety functions during and immediately after an earthquake.

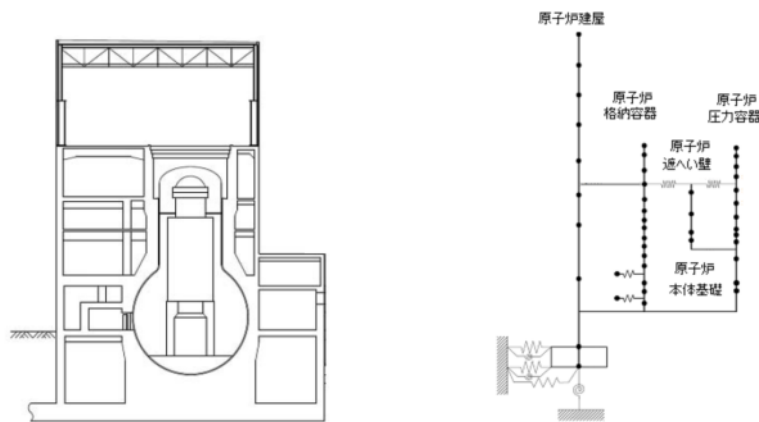
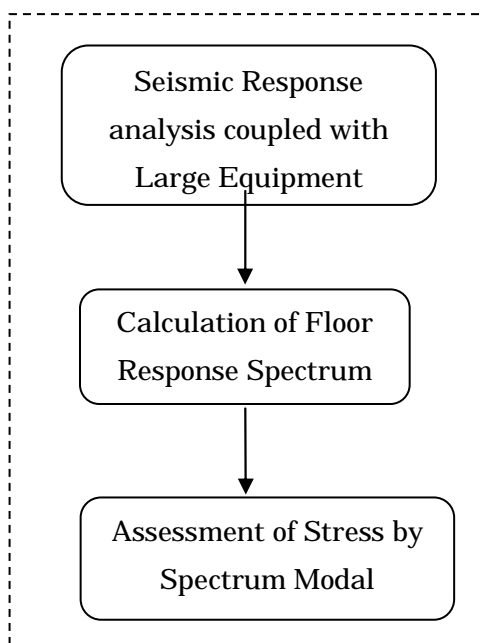


Fig-4 Example of Seismic Response Analysis Model coupled with Large Equipment

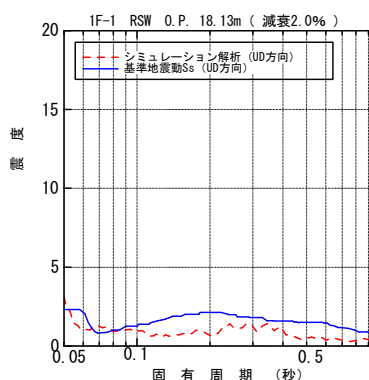
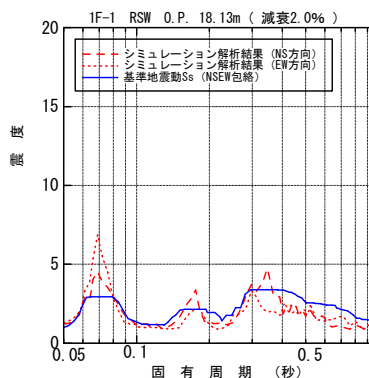
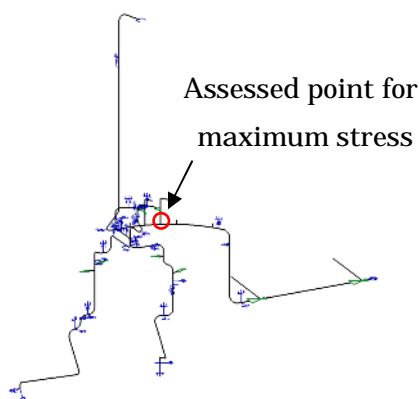
Table-1 Summary of Assessment of Effects on Equipment and Piping important to Seismic Safety (Unit 1 of Fukushima Dai-ichi NPS)

Equipment	Seismic Response Load	Standard Seismic Motion S <sub>s</sub>	Results of Simulated Analysis	Results of Seismic Assessment	
Seismic Load	Reactor Pressure Vessel Base	Shearing Force (kN)	4730	6110	Reactor Pressure Vessel (Base bolt) Calculated value: 93MPa Assess. Reference: 222MPa
		Moment (kN · m)	45900	62200	
		Axial force (kN)	5250	3890	
	Primary Containment Vessel Base	Shearing force (kN)	4270	5080	Primary Containment Vsl. (Drywell) Calcu. value : 98MPa Assess. Reference : 411MPa
		Moment (kN · m)	55900	64200	
		Axial force (kN)	2070	1560	
	Core Shroud Base	Shearing force (kN)	3060	3370	Core Support Structure (Shroud support) Calcy. value : 103MPa Assess. Reference : 196MPa
		Moment (kN · m)	15300	16600	
		Axial force (kN)	1020	792	
	Fuel Assembly	Relative Displacement (mm)	21.2	26.4	Control Rod (inserting) Assess. Reference : 40.0mm
Seismic Intensity for Assessment	Fuel Exchange Floor	Seismic Intensity (horizon) (G)	0.96	1.29	Reactor Shut-down Cooling System Pump (Base bolt) Calcu. value : 8MPa Assess. Reference : 127MPa
		Seismic Intensity (vertical) (G)	0.58	0.54	
	Base Mat	Seismic Intensity (horizon) (G)	0.60	0.57	
		Seismic Intensity (vertical) (G)	0.51	0.32	
Floor Response Spectrum (Reactor Bldg.)	< Reactor Building (O.P.18.70m) >			Main Steam System Piping Calcu. value : 269MPa Assess. Reference : 374MPa  Reactor Shut-down Cooling System Piping Calcu. value : 228MPa Assess. Reference : 414MPa	
	<p>(horizontal)</p>	<p>(vertical)</p>			
Floor Response Spectrum (Core Shielding Wall)	< Reactor Shielding Wall (O.P.16.14m) >				
	<p>(horizontal)</p>	<p>(vertical)</p>			

## Reference: Summary of Seismic Assessment (Example of Main Steam System Piping)



Assessment Flow



Floor Response Spectrum

\*Image of inputting to anchors and supports (blue marks in the diagram)

### Main Steam System Piping Model

#### Results of Assessment for Structural Intensity

Equipment	Assessed Part	Standard Seismic Motion Ss				the March 11 Earthquake			
		Stress Category	Calcu. value (MPa)	Assess. Reference (MPa)	Assess. method	Stress Category	Calcu. value (MPa)	Assess. Reference (MPa)	Assess. method
Main Steam System Piping	Piping body	Primary	287	374	Details	Primary	269	374	Details

\* : Taking into account that the vertical floor response spectrum is roughly below that of the standard seismic motion  $S_s$ , although the horizontal floor response spectrum of the March 11 earthquake exceeds the standard seismic motion  $S_s$  in some cyclic bands, it is considered that the calculated values of the March 11 earthquake were below those of the standard seismic motion  $S_s$ .