Fukushima Daiichi Nuclear Power Station Unit No. 3
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 3 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 3, 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 0.17×10^{-3} (east-west direction, 5F), 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.

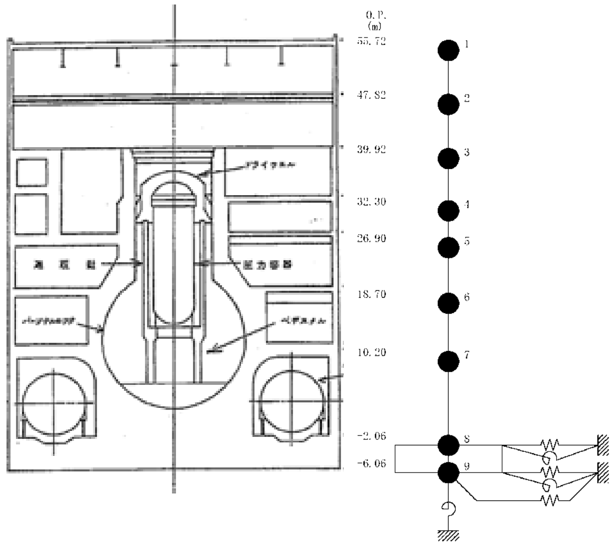


Fig. 1 Model of Unit 3 reactor building

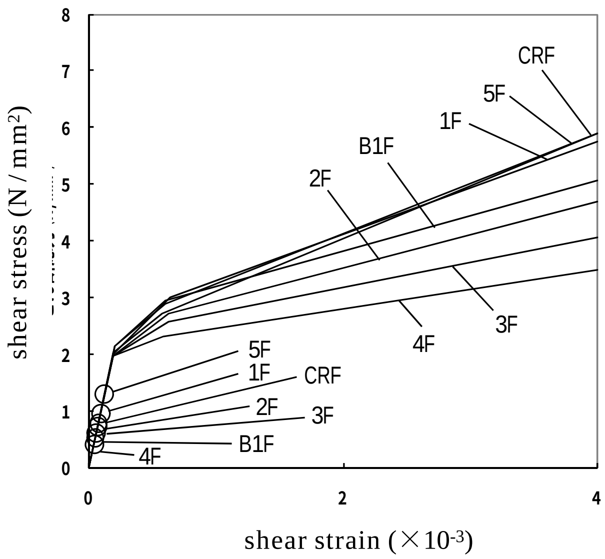


Fig. 2 Shear strain of seismic wall
(north-south direction)

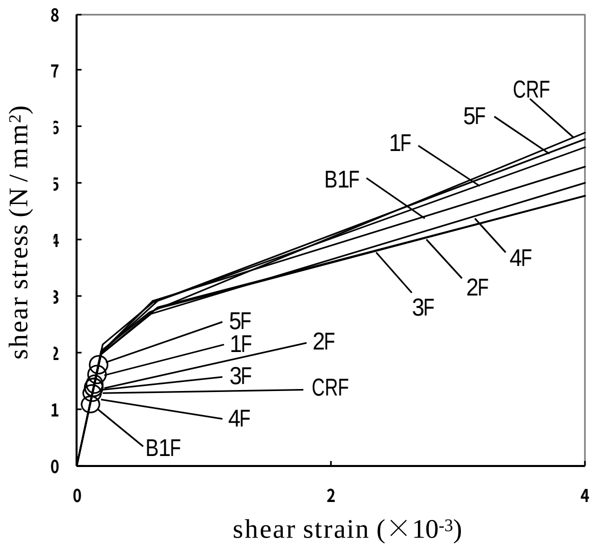


Fig. 3 Shear strain of seismic wall
(east-west direction)

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 3 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 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.

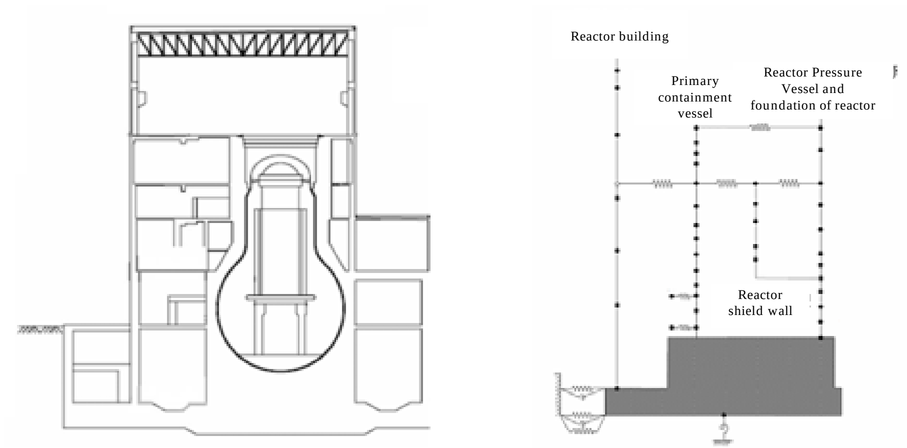
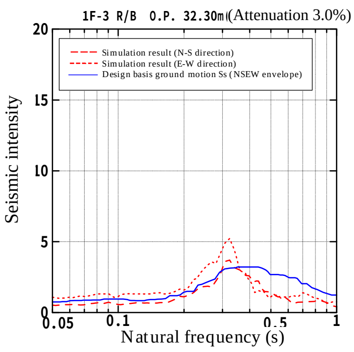
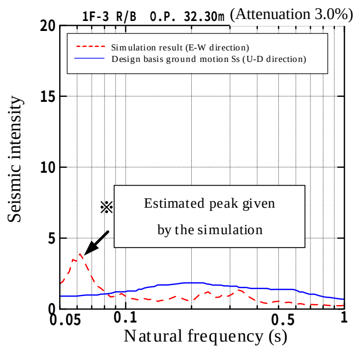


Fig. 4 Example of large equipment coupled earthquake response analysis model

Table 1 Summary of the assessment of important equipment and the piping system for earthquake resistant safety (Fukushima Daiichi Nuclear Power Station, Unit 3)

<table>
<tr><th colspan="2">Equipment</th><th colspan="2">Earthquake response stress</th><th>design basis ground motion Ss</th><th>Simulation results</th><th>Results of seismic safety assessment</th></tr>
<tr><td rowspan="10">Seismic load and etc.</td><td rowspan="3">Reactor pressure vessel Base</td><td>Shear force</td><td>(kN)</td><td>4970</td><td>5750</td><td rowspan="3">Reactor pressure vessel (foundation bolt)
Calculated result: 50MPa
Criterion: 222Mpa</td></tr>
<tr><td>Moment</td><td>(kN·m)</td><td>30400</td><td>41700</td></tr>
<tr><td>Axial force</td><td>(kN)</td><td>5780</td><td>4900</td></tr>
<tr><td rowspan="3">Primary containm ent vessel Base</td><td>Shear force</td><td>(kN)</td><td>7070</td><td>8150</td><td rowspan="3">Primary containment vessel (drywell)
Calculated result: 158MPa
Criterion: 278MPa</td></tr>
<tr><td>Moment</td><td>(kN·m)</td><td>123000</td><td>153000</td></tr>
<tr><td>Axial force</td><td>(kN)</td><td>2930</td><td>2080</td></tr>
<tr><td rowspan="3">Core shroud Base</td><td>Shear force</td><td>(kN)</td><td>2440</td><td>3010</td><td rowspan="3">Core supporter (shroud supporter)
Calculated result: 100MPa
Criterion: 300MPa</td></tr>
<tr><td>Moment</td><td>(kN·m)</td><td>13600</td><td>16600</td></tr>
<tr><td>Axial force</td><td>(kN)</td><td>783</td><td>681</td></tr>
<tr><td>Fuel assembly</td><td>relative displacement</td><td>(mm)</td><td>14.8</td><td>24.1</td><td>Control rod(insertion)
Criterion: 40.0mm</td></tr>
<tr><td rowspan="4">Seismic intensity</td><td rowspan="2">Fuel exchange floor</td><td>Intensity (horizontal)</td><td>(G)</td><td>0.95</td><td>1.34</td><td rowspan="4">Residual heat removal pump (motor mounting volt)
Calculated result: 42MPa
Criterion: 185Mpa</td></tr>
<tr><td>Intensity (vertical.)</td><td>(G)</td><td>0.57</td><td>0.81</td></tr>
<tr><td rowspan="2">Base mat</td><td>Intensity (horizontal)</td><td>(G)</td><td>0.55</td><td>0.61</td></tr>
<tr><td>Intensity (vertical.)</td><td>(G)</td><td>0.53</td><td>0.29</td></tr>
<tr><td>Floor response spectrum (reactor building)</td><td colspan="5">< Middle layer (O.P.32.30m) >


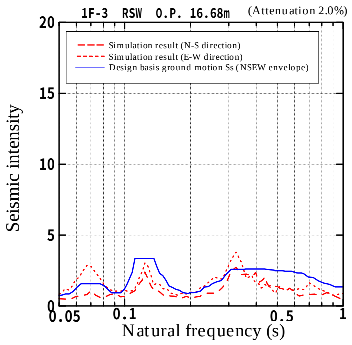
(Horizontal)


(Vertical)</td><td>Main steam system pipe
Calculated result: 151MPa
Criterion: 378MPa

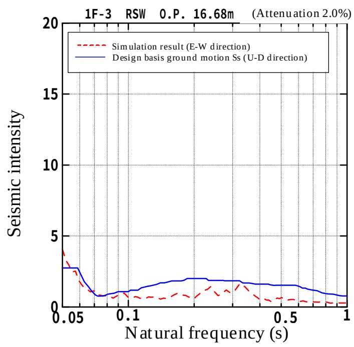
Residual heat removal system pipe
Calculated result: 269MPa
Criterion: 363MPa</td></tr>
</table>

床応答スペクトル（原子炉遮へい壁）

<Middle of reactor shield wall (O.P.32.30m)>



(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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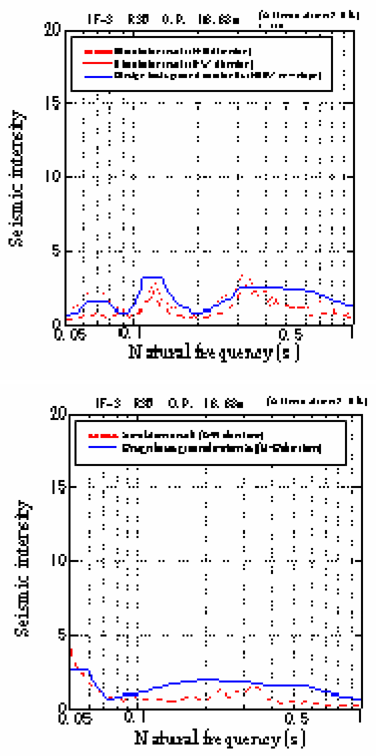
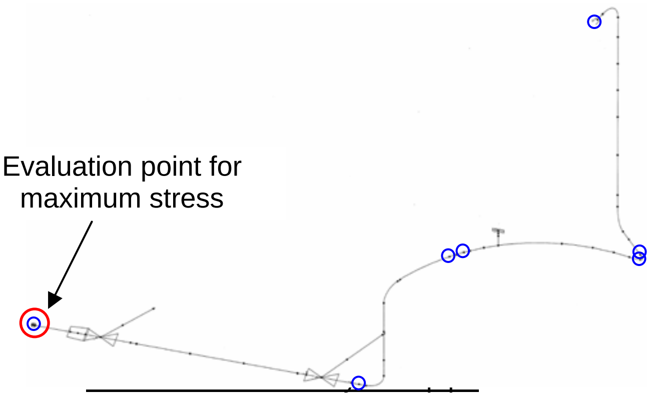
Evaluation of stress by spectrum modal analysis

Flowchart of assessment



Floor response spectrum



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

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	183	417*	Detail	Primary	151*	378*	Detail

* Criteria for Design basis ground motion Ss and this earthquake are different since materials of the pipe at evaluation point for maximum stress (least margin point) are different.

End