Revised

Results of the Seventh Soundness Inspection for Unit 4 Reactor Building at Fukushima Daiichi Nuclear Power Station

December 18, 2013

Tokyo Electric Power Company

TEPCO 東京電力

1. Purpose of Inspection

Unit 4 Reactor Building and Spent Fuel Pool are inspected on a regular basis (four times a year) for soundness. The inspections were done six times before. Based on the results, it was confirmed that the spent fuel can be stored safely. The seventh regular inspection was performed as follows.

[Overview of the regular inspections performed]

(1) First regular inspection (May 17-25, 2012)
(2) Second regular inspection (August 20-28, 2012)
(3) Third regular inspection (November 19-28, 2012)
(4) Fourth regular inspection (February 4-12, 2013)
(5) Fifth regular inspection (May 21-29, 2013)
(6) Sixth regular inspection (August 6-28, 2013)
[Inspection items] 1. Water level measurement, 2. Outer wall measurement, 3. Visual inspection, 4. Concrete strength evaluation
[Outline of the results] No crack or building tilt was found and a sufficient level of concrete strength was maintained. The condition allows for safe storage of spent fuel. No significant change was found from the first regular inspection results.

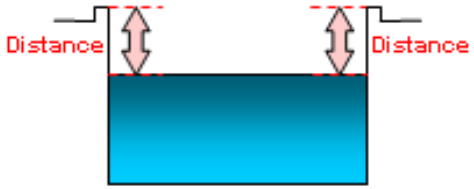
(7) Seventh regular inspection (November 26-December 18, 2013)
[Inspection items] 1. Water level measurement, 2. Outer wall measurement, 3. Visual inspection, 4. Concrete strength evaluation

2. Results (1) Building Tilt Measurement (Water Level)

Given that the water surface is always horizontal, the distances between the 5th floor surface and the water levels of the reactor well and spent fuel pool were measured to check if the building is tilted or not.

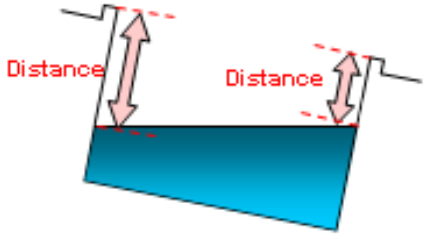
[Results of the former inspections] It has already been confirmed that the building is not tilted based on the measurement results obtained on February 7, April 12, May 18, August 21, November 20, 2012, February 6, May 21, and August 6, 2013.

1) Building not tilted

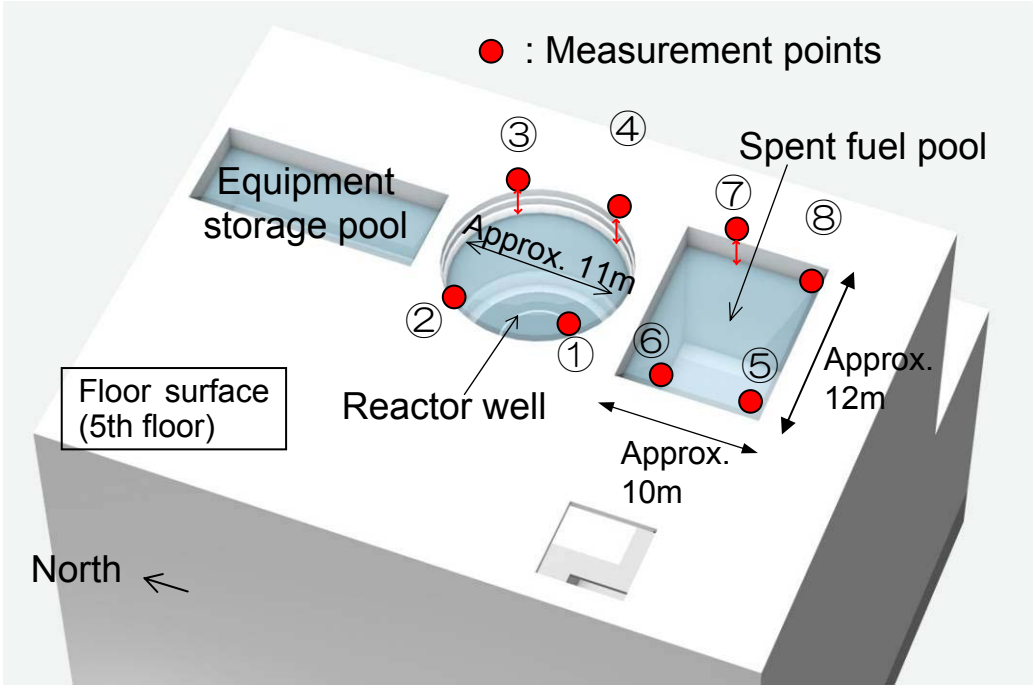


The distances are the same

2) Building tilted



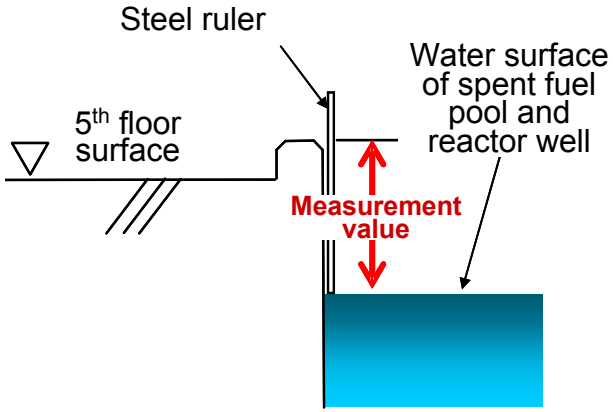
Difference in the distances



Measurement points (Floor surface of the 5th floor)

2. Results (1) Building Tilt Measurement (Water Level)

Considering that the water level measurement values on the four corners were about the same, it has been concluded that the 5th floor surface and the water surfaces of the spent fuel pool and the reactor well are parallel and the building is not tilted similarly to the past results.



Measurement method*1

Water level*2 measurement results

Unit [mm]

Reactor well	Measurement date								
	Feb. 7, 2012	Apr. 12, 2012	May 18, 2012	Aug. 21, 2012	Nov. 20, 2012	Feb. 6, 2013	May 21, 2013	Aug. 6, 2013	Nov. 28, 2013
①	462	476	492	462	463	465	467	465	481
②	463	475	492	462	464	464	465	465	481
③	462	475	492	461	463	463	464	465	482
④	464	475	492	461	463	463	465	466	482

Spent fuel pool	Measurement date								
	Feb. 7, 2012	Apr. 12, 2012	May 18, 2012	Aug. 21, 2012	Nov. 20, 2012	Feb. 6, 2013	May 21, 2013	Aug. 6, 2013	Nov. 28, 2013
⑤	— (*3)	468	461	453	443	444	439	448	490
⑥		468	461	453	444	443	439	446	490
⑦		468	461	452	442	443	439	446	490
⑧		468	461	452	443	443	438	446	489

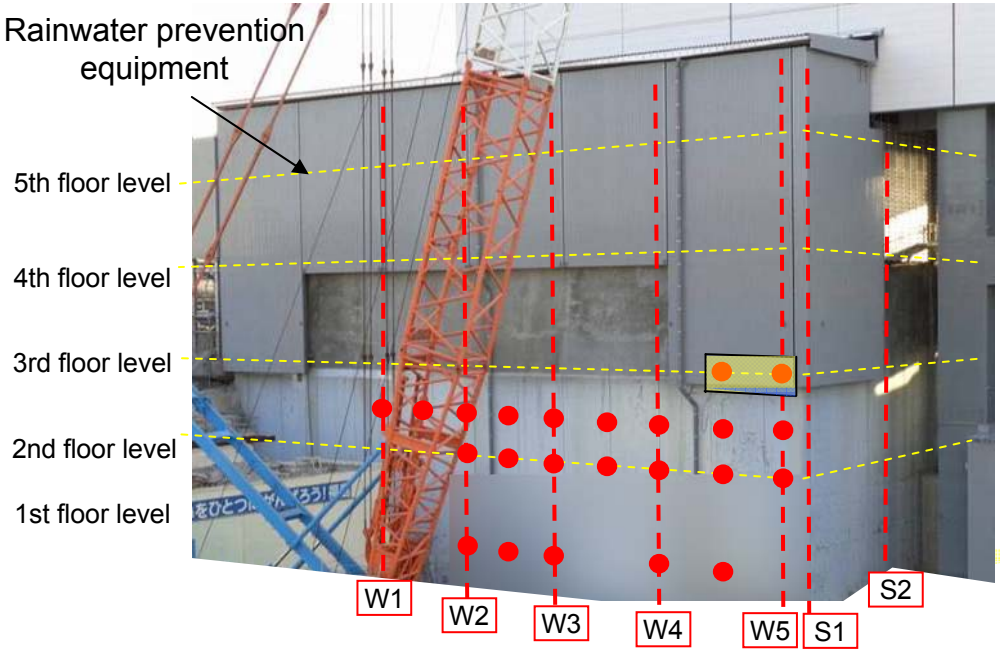
*1 Error must be taken into account as the measurement is done visually by a person
*2 Water levels are subject to change daily depending on the operation status of cooling equipments.
*3 On February 7, 2012, measurement was done only on the reactor well.

2. Results (2) Outer Wall Measurement (Measurement Points)

- The horizontal differences*1 of the outer walls were measured by an optical equipment (with fixed points set on the upper and lower sides of the walls) and the deformation characteristics of the outer walls were evaluated.
- The south wall was excluded from the measurement due to interference with the cover for fuel removal.
- 2 points of the third floor level were excluded from the measurement due to interference with rainwater prevention equipment of the Reactor Building.

[Results of the former inspections]

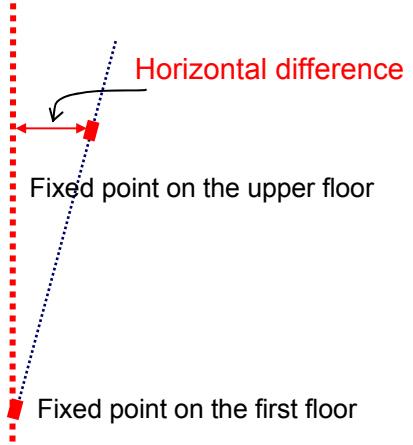
Though partial bulge was found on the outer walls, it has been confirmed that the building itself is not tilted based on the results of the first regular inspection (May 2012), detailed inspection of outer walls (June 2012), and second to sixth regular inspections (August and November 2012, February, May, and August 2013).



[Legend] ●: Measurement point ▭: Area where measurement was impossible
W: West S: South

Measurement points

*1 Horizontal distance between the fixed point on the first floor and the fixed point on the upper floor



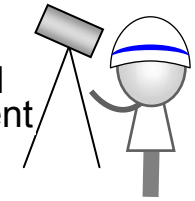


Image processing was partially applied for the purpose of physical protection.

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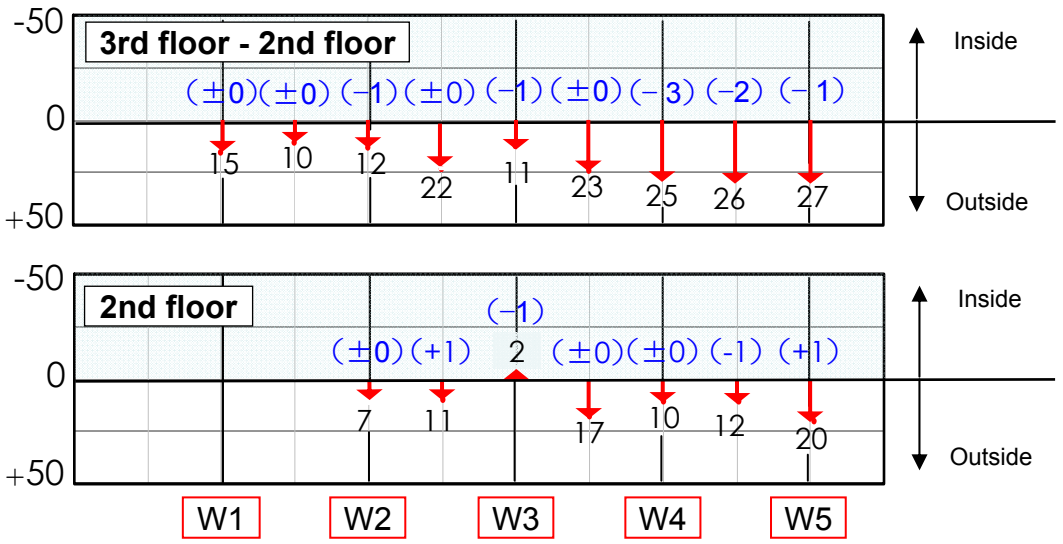
2. Results (2) Outer Wall Measurement (Measurement Results)

[Legend] ( ): Difference from the previous inspection results
(Previous horizontal difference − horizontal difference measured this time)
W: West



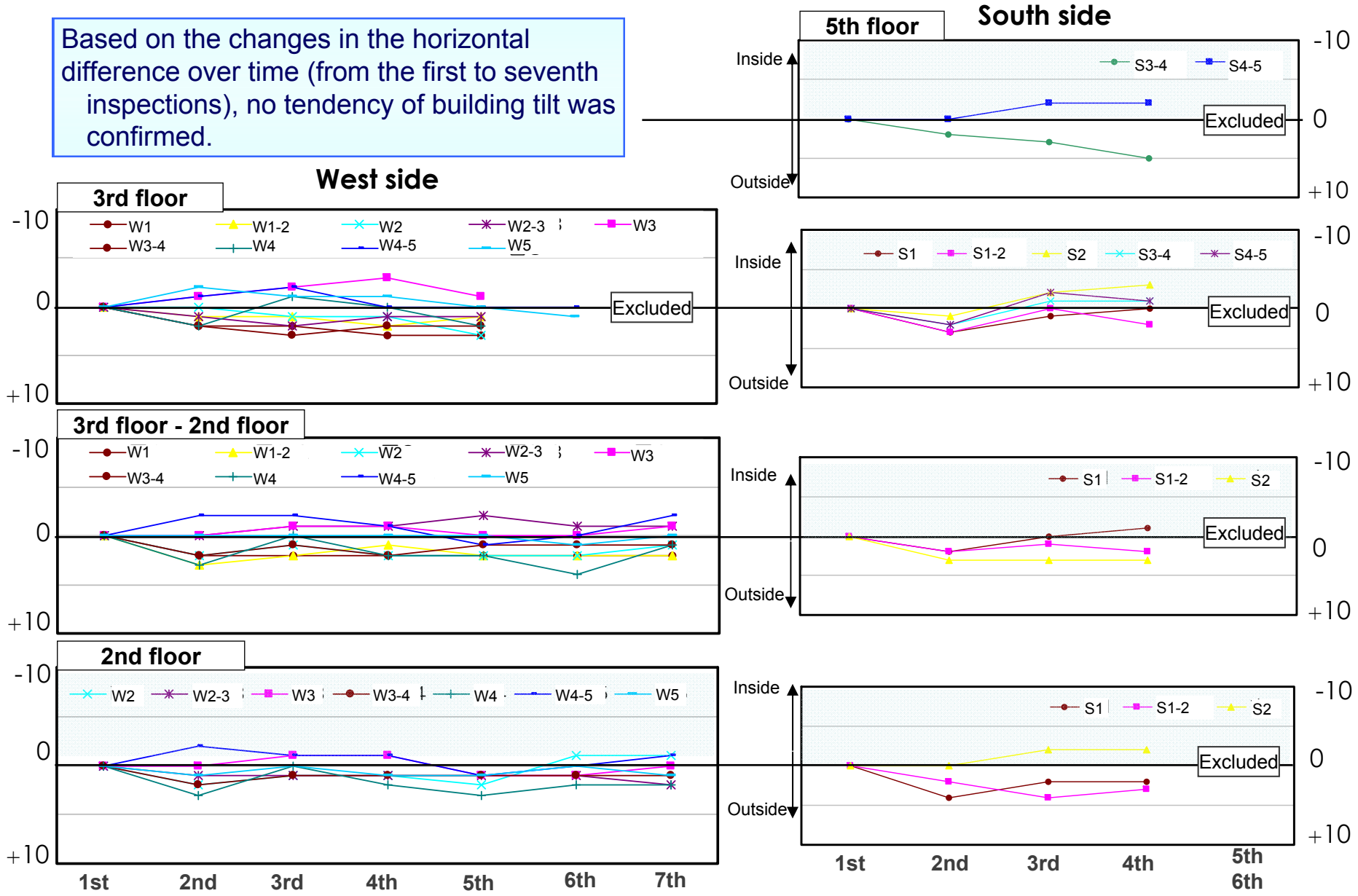
*1 Horizontal distance between the fixed point on the first floor and the fixed point on the upper floor

Horizontal difference*1 calculation results (Unit: mm)

(Reference)
Average temperature during the previous inspection*2: 25.2ºC
Average temperature during the present inspection*2: 9.1ºC
*2 Calculated using weather data of Namie obtained from the Japan Meteorological Agency website

2. Results (2) Outer Wall Measurement (Measurement Results)

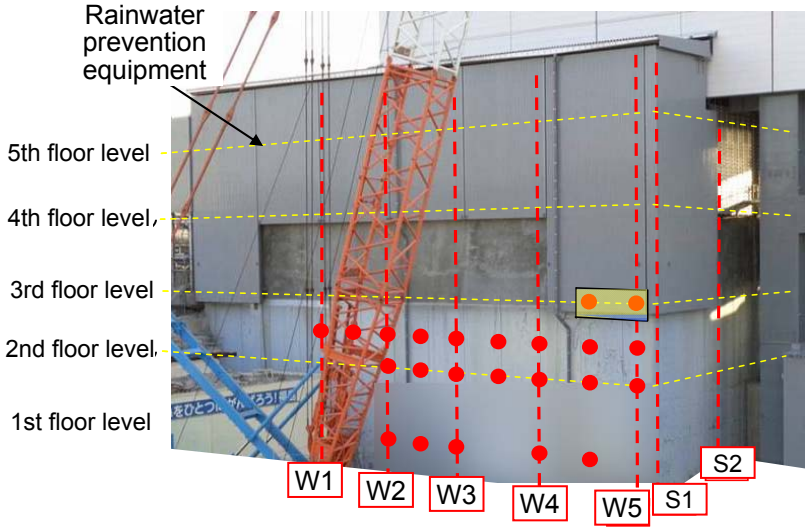
Based on the changes in the horizontal difference over time (from the first to seventh inspections), no tendency of building tilt was confirmed.

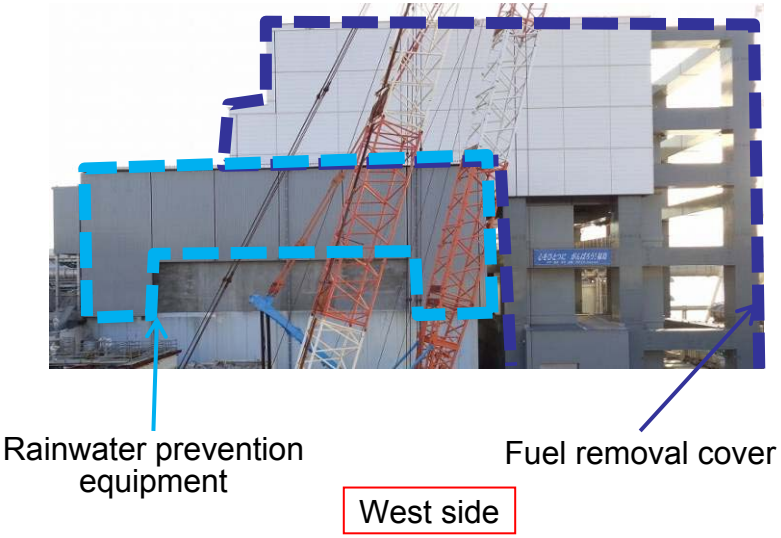


Changes in the horizontal difference over time (Unit: mm)

2. Results (2) Outer Wall Measurement (Consideration)

- The horizontal differences measured this time were about the same as those in the first to sixth inspections, and the deformation characteristics on the measurement points were also similar.
- The small difference from the previous measurement results may be due to factors such as error of the optical equipment (Measurement error of ±2mm may cause approx. 4mm (Max.) error in horizontal difference) and thermal expansion of concrete (thermal expansion coefficient: Approx. 7-13×10^{-6}/°C) which may cause approx. 5-9mm error because of the difference of average monthly temperatures between August and November.
- Some measurement points on the south and the south-west walls were excluded from the present and future measurements due to interference with the cover for fuel removal, and rainwater prevention. However, we consider that no significant change would be found with the measurement on the outer surface of the south wall, since no significant change was found with measurement results on the west wall and the inspection results for the other three inspection items.

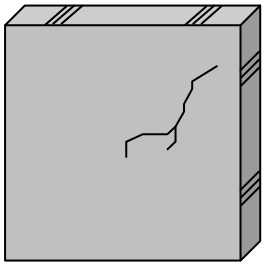




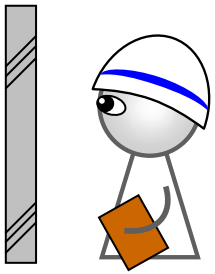
2. Results (3) Visual Inspection (Plan, Criteria)

Visual inspection was done on the concrete floor and walls. In the case that a crack of a width of 1mm or more is found, repair must be done as appropriate.

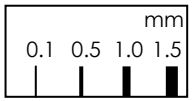
[Results of the former inspections] No crack of a width of 1mm or more was found in the first inspection (May 2012), the detailed inspection of outer walls (June 2012) and the second to sixth inspections (August, November 2012 and February, May, August 2013).



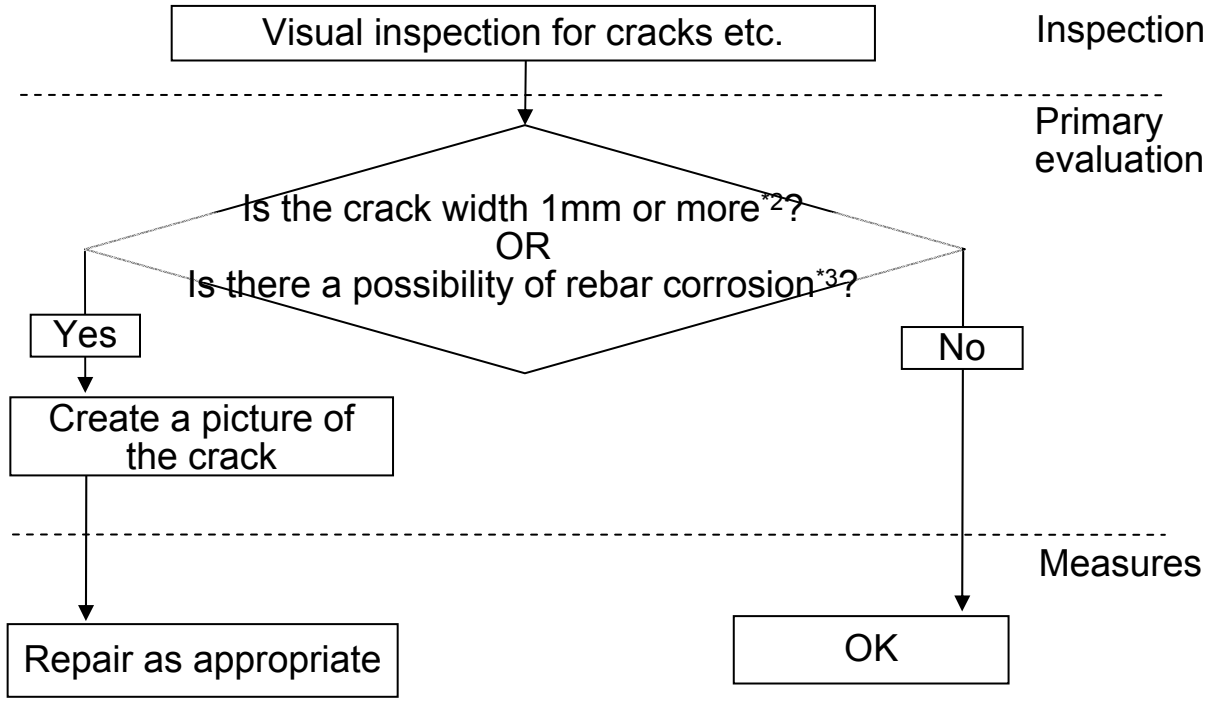
Check for cracks on the walls and the floor



Visual inspection



Crack scale*1



Flow of visual inspection

*1 Crack scale: Used to measure the width of a crack. (The scale is placed on a crack to measure its width.)
*2 In the case that the crack width is 1mm or more, the durability of the building must be reviewed in accordance with the "Maintenance and Management of Structures in Nuclear Facilities" specified by the Architectural Institute of Japan.
*3 In the case that rebar corrosion which may affect the building durability is found on the inspected area.

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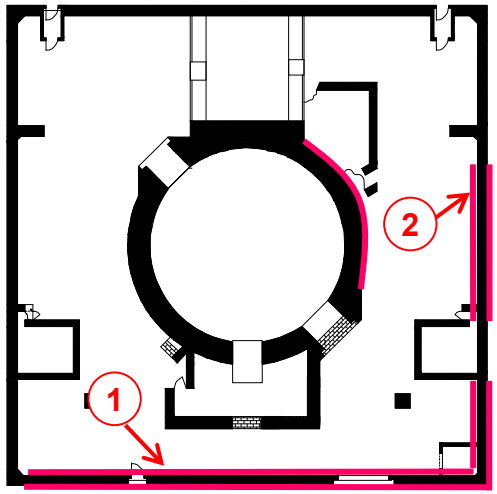
2. Results (3) Visual Inspection (Results)

Since no crack of a width of 1mm or more or with possible rebar corrosion was found as a result of visual inspection (similarly to the past results).

[Legend] ▬: Inspected areas



First floor

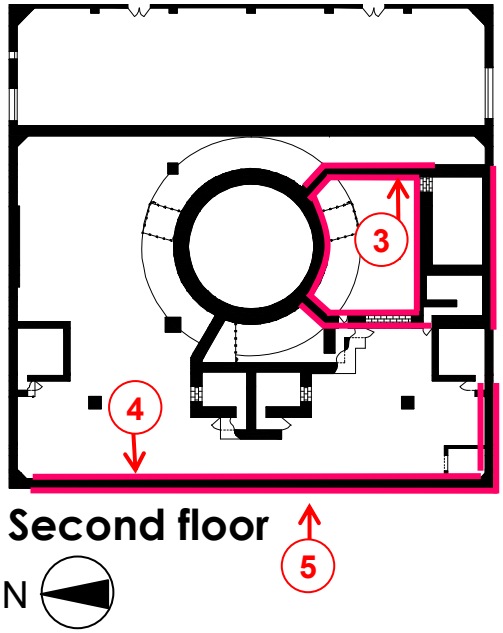
N

① **West wall (inner surface)**

② **South wall (inner surface)**

2. Results (3) Visual Inspection (Results)

[Legend] ——: Inspected areas



③ SFP side wall

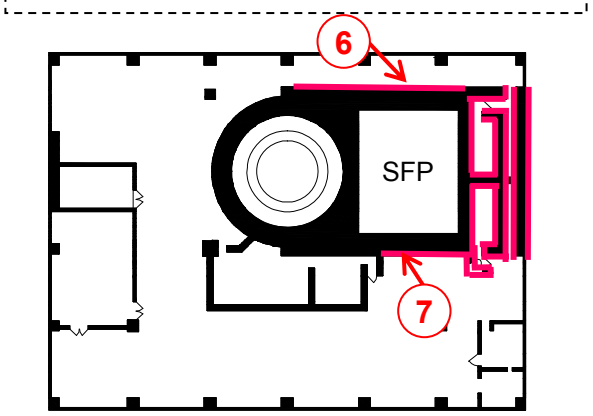
④ West wall (inner surface)

⑤ West wall (outer surface)

*SFP: Spent fuel pool

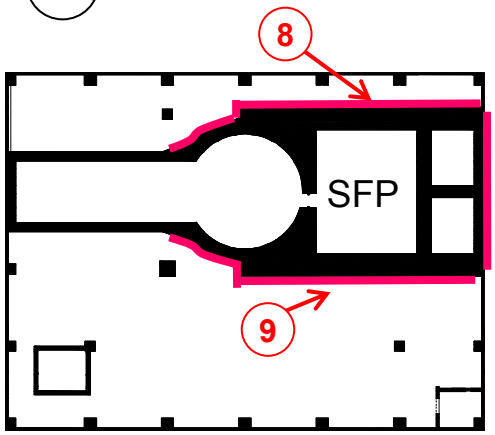
2. Results (3) Visual Inspection (Results)

[Legend] —: Inspected areas



Third floor

N



Fourth floor

N

⑥ SFP side wall (East side)

⑦ SFP side wall (West side)

⑧ SFP side wall (East side)

⑨ SFP side wall (West side)

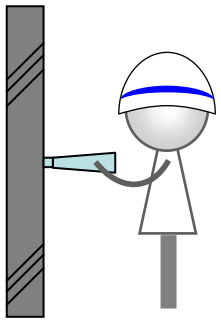
*SFP: Spent fuel pool

2. Results (4) Concrete Strength Evaluation (Plan, Criteria)

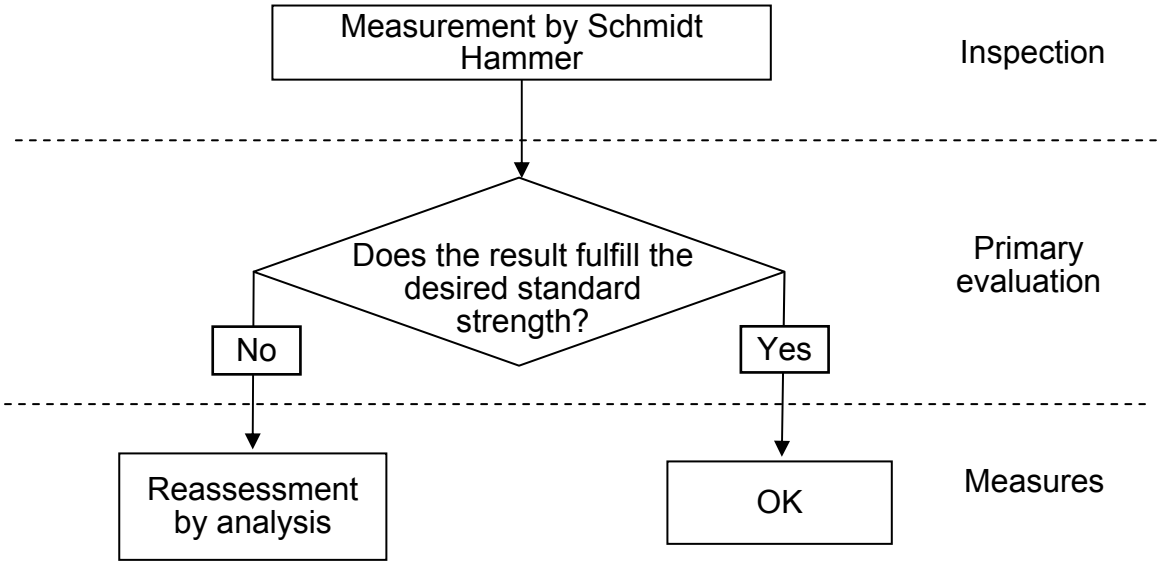
The concrete strength of the spent fuel pool frame was evaluated*1 by non-destructive inspection technique (Schmidt Hammer*1) to confirm that the strength fulfills the design standard.

[Results of the former inspections]

The concrete strength fulfilled the design standard in the first inspection (May 2012), the detailed inspection of the outer walls (June 2012) and the second to fifth inspections (August, November 2012 and February, May, and August 2013).



Non-destructive inspection (Schmidt Hammer*1)

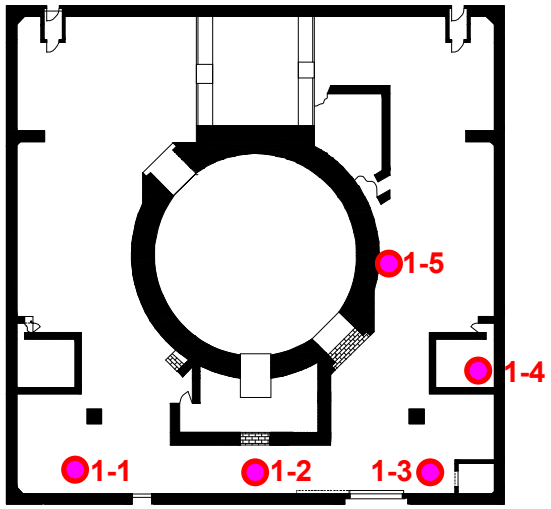


Flow of non-destructive inspection

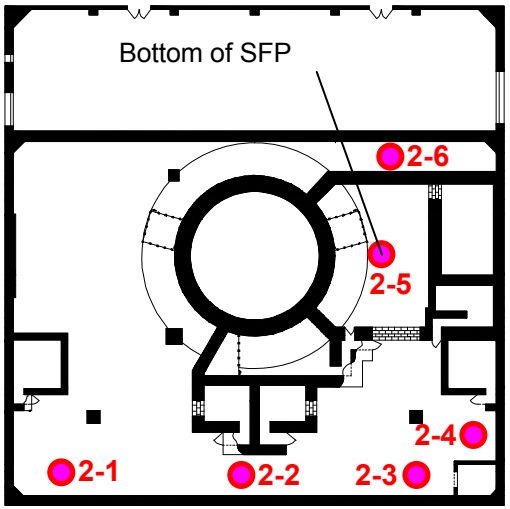
*1 Schmidt Hammer Technique: A non-destructive inspection technique to estimate concrete strength by hammering the concrete and measuring the impact returned.

2. Results (4) Concrete Strength Evaluation (Measurement Points)

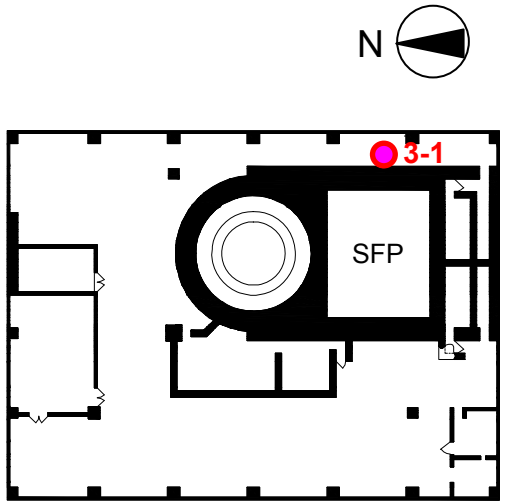
The concrete strength measurement points*1 are indicated below.



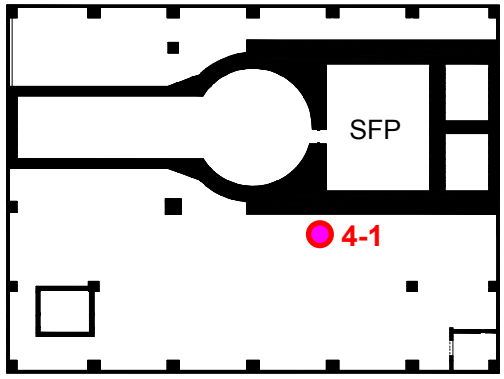
First floor



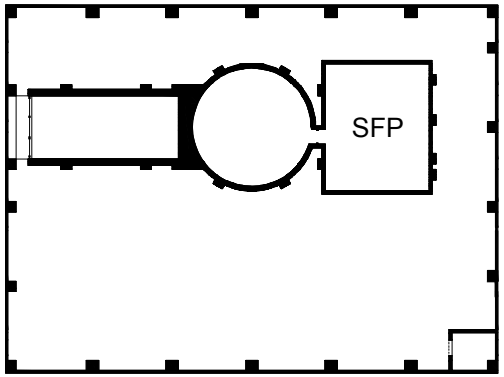
Second floor



Third floor



Fourth floor



Fifth floor

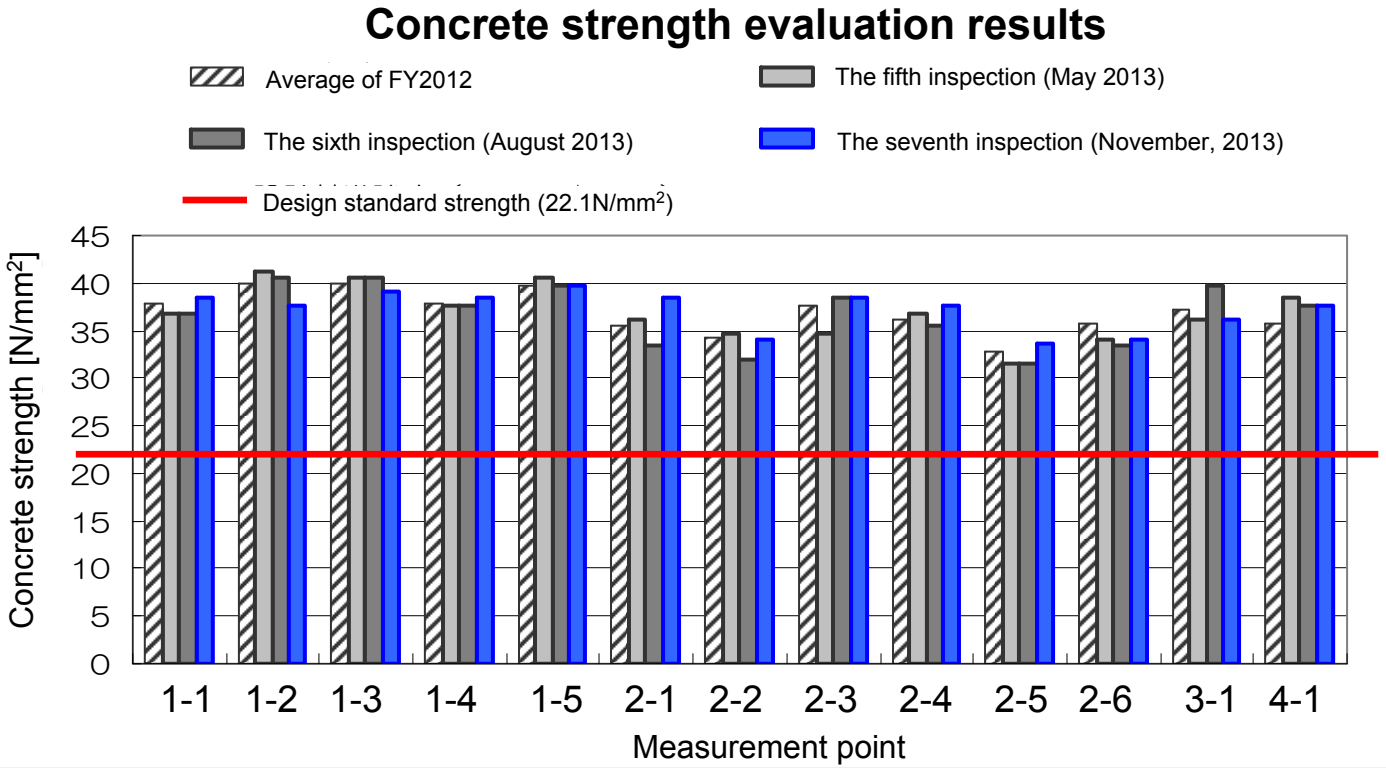
[Legend] ●: Measurement points

*1 The measurement points were set at slightly different locations from the previous measurement points.

2. Results (4) Concrete Strength Evaluation (Result)

As a result of measurement, the concrete strengths on all the measurement points were above the design standard (22.1N/mm^2) similarly to the past results. The concrete strength is considered to be about the same as the past results taking into considerations the error of Schmidt Hammer*1 and that the measurement points were set at slightly different locations from the previous ones.

*1 Error of approx. 3N/mm^2 is assumed for the experimental value and the strength criterion formula according to the "Guidelines for evaluation of concrete compressive strength by Schmidt Hammer" (August 1958, Material Testing Research Association of Japan).



＊ The numbers of the measurement points were incorrect. We revised them and apologize for the correction.

Summary

- As a result of the seventh inspection, it is concluded that the building is not tilted and a sufficient concrete strength is maintained with no cracks that would affect the structural strength of the building.

- The condition of Unit 4 Reactor Building has not changed much from the first to sixth inspections and is capable of safely storing the spent fuel pool.

- The inspection will be conducted on a regular basis in order to check for changes over time.

- The visual inspection was performed with an outside expert (Professor Kazuo Tamura at Chiba Institute of Technology).

- Additionally, the present inspection results were reviewed by another outside expert (Professor Katsumi Takiguchi at Tokyo Institute of Technology) with whom the previous inspection was performed.

Comments and Feedbacks from Outside Experts

Professor Kazuo Tamura at Chiba Institute of Technology:

-The displacement measuring for outer walls should be continued for a long-term because it is effective for comprehending the whole behavior of turbine buildings.

Professor Katsumi Takiguchi at Tokyo Institute of Technology:

- As for regular inspections, the frequency of inspection for each item could be reconsidered; for example, a visual inspection is held once per six months, others once a year.
- Currently, both 'water level' and 'outer wall surface' are measured, in order to check the tilt of the turbine buildings. However, the results of the inspections so far suggest a lower frequency of the two kinds of inspections. An inspection with smaller exposure dose could be administered mainly.
- Visual inspections should be flexibly conducted not only in regular inspections, but also every time when an earthquake stronger than the ones recorded in the neighbourhood of the power stations after Tohoku-Chihou-Taiheiyou-Oki Earthquake occurs, so that we could make sure of no changes.

Visual inspection for South outer wall [On the left]*

Visual inspection at a turbine building [On the left]*

*Photos taken on December 13, 2013

Professor Tamura (Chiba Institute of Technology) accompanying the inspection

End