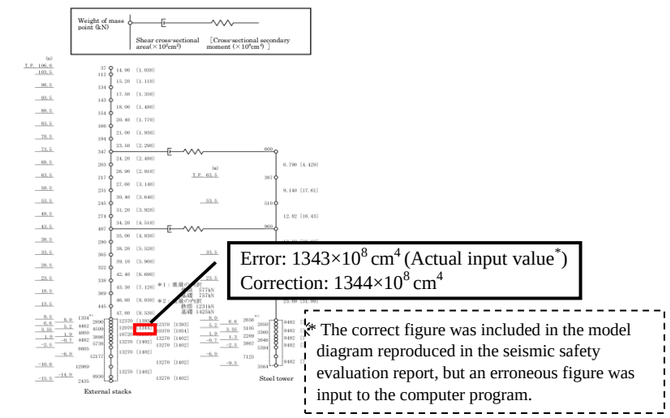
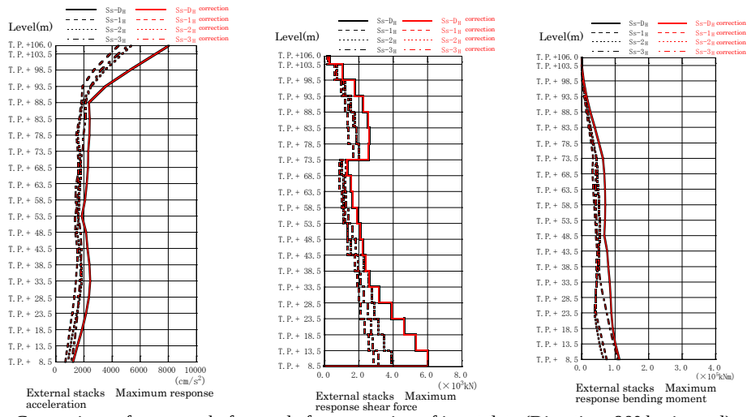
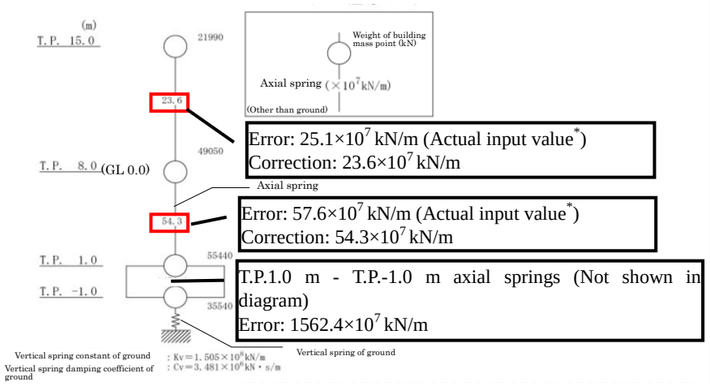
Content, Impact and Cause Analysis of Input Data Errors in Seismic Safety Evaluation Reports for Hamaoka Nuclear Power Station Reactors No. 3, 4 and 5 (Outline)

Attachment 2

Item	Details of error	Impact on evaluation of seismic safety	Analysis of cause by contractor
(1)	During the input of data for analysis of the EW seismic response of the Unit No. 5 reactor building to the computer program, a key error resulted in the input of one erroneous figure in data concerning the relationship between bending moment and strain for the earthquake-resistant walls (the bending moment value of the secondary breakpoint*). (Error) 289.9 × 10^6 t・cm → (Correction) 280.9 × 10^6 t・cm *For the relationship between bending moment and strain for an earthquake-resistant wall, the primary breakpoint is the range of elasticity of the concrete, and the secondary breakpoint is the range of elasticity of the reinforcing steel.	・Because the response value determined in the analysis was lower than the primary breakpoint,* which was lower than the secondary breakpoint,* the results of the analysis were unchanged irrespective of the input error.	Contractor (Company A): ・At the time of the analysis (January 2007), a method of checking that data had been correctly input had not yet been established in in-house rules. ・Because of this, despite the fact that the staff members responsible for the analysis checked the screen after inputting each figure based on materials documenting bases for input, in the one case indicated, the figure was not checked on the input screen. It is believed that the figure was overlooked because it was difficult to discriminate between figures on the screen. ・In addition, because no staff members other than those responsible for conducting the analysis checked that the data had been correctly input, the error was not discovered.
(2)	During the input of data for analysis of the horizontal seismic response of the Unit No. 5 exhaust stacks (external stacks) to the computer program, a key error resulted in the input of one erroneous figure for the cross-sectional secondary moment of the base.  Error: 1343×10^8 cm^4 (Actual input value*) Correction: 1344×10^8 cm^4 *The correct figure was included in the model diagram reproduced in the seismic safety evaluation report, but an erroneous figure was input to the computer program. Seismic response analysis model of Unit No. 5 exhaust stack (Horizontal model specifications)	・While the results of the analysis using the correct data indicated that some corrections were necessary in the report, it has been determined that the error had no impact on the evaluation of the seismic safety of the reactor facilities.  Comparison of response before and after correction of input data (Direction: 90° horizontal)	Contractor (Company A): ・At the time of the analysis (March 2007), a method of checking that data had been correctly input had not yet been established in in-house rules. ・Because of this, despite the fact that the staff members responsible for the analysis checked the screen after inputting each figure based on materials providing bases for input, in the one case indicated, the figure was not checked on the input screen. It is believed that the figure was overlooked because it was difficult to discriminate between figures on the screen. ・In addition, because no staff members other than those responsible for conducting the analysis checked that the data had been correctly input, the error was not discovered.

(3)

In three separate cases, figures for the axial springs, part of the data for analysis of vertical seismic response in the Unit No. 5 seawater heat exchanger building, which should have been input based on the 1999 edition of the Standard for Structural Calculation of Reinforced Concrete Structures (“RC Standard” below), were instead input based on the 1991 edition.



Error: 25.1×10^7 kN/m (Actual input value*)
Correction: 23.6×10^7 kN/m

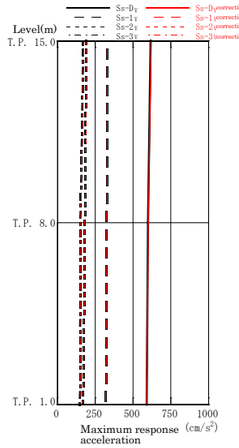
Error: 57.6×10^7 kN/m (Actual input value*)
Correction: 54.3×10^7 kN/m

T.P.1.0 m - T.P.-1.0 m axial springs (Not shown in diagram)
Error: 1562.4×10^7 kN/m

* The correct figure was included in the model diagram reproduced in the seismic safety evaluation report, but an erroneous figure was input to the computer program.

Seismic response analysis model of Unit No. 5 seawater heat exchanger building (Vertical direction)

・ While the results of the analysis using the correct data indicated that some corrections were necessary in the report, the error had no impact on the evaluation of the seismic safety of the reactor facilities.



Comparison of response before and after correction of input data (Black lines: Errors; Red lines: Corrections)

Results of evaluation employing correct data

Subject of follow-up evaluation	Evaluation status	Generated values (MPa)	Evaluation benchmark values (MPa)
Reactor equipment cooling seawater system pipes	Before follow-up evaluation	175	354
	After follow-up evaluation	176	
Reactor equipment cooling seawater system pipe supports	Before follow-up evaluation	203	245
	After follow-up evaluation	200	
Reactor equipment cooling seawater system vortex strainers	Before follow-up evaluation	121	328
	After follow-up evaluation	121	

Contractor (Company A):

・Corrections were made based on analysis models formulated during the design process with reference to the latest standards, etc., and these were employed in analyses for the evaluation of seismic safety. The analysis models formulated at the time of design (around July 1998) were produced using specifications (weight, axial spring, and vertical spring of ground) based on the 1991 RC Standard. However, at the time of the analysis (January 2007), the RC Standard had been revised in 1999, making correction of the specifications necessary.

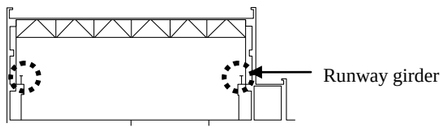
・At the time of the analysis, in-house rules had not been established specifying the formulation of documents clearly setting out the bases for input and providing methods for verifying correct input of input data. Because of this, the members of staff responsible for the analysis brought up design data on the screen and replaced figures calculated using 1991 RC Standard data with figures that they calculated on a calculator, one by one, using 1999 RC Standard data, without formulating materials documenting bases for input that indicated where corrections had been made. During this process, the values for the axial springs were overlooked and not corrected.

・In addition, following correction of the data, neither the members of staff responsible for conducting the analysis nor any other members of staff verified whether the data had been appropriately corrected, and the errors were therefore not discovered.

(4)

Due to a misunderstanding, an incorrect coefficient (0.4) was employed in calculating vertical load for the evaluation of the reactor building ceiling crane runway girders for Units No. 3 and 4 (one instance for each unit, for a total of two instances).

・Calculation of vertical load due to weight of runway girder
(Error)W×α_V×0.4 → (Correction)W×α_V×1.0
(W: Weight of runway girder; α_V: Vertical seismic intensity)



Schematic diagram of reactor building ceiling crane runway

・While the results of the analysis using the correct data indicated that some corrections were necessary in the report, the error had no impact on the evaluation of the seismic safety of the reactor facilities.

Results of evaluation employing correct data (Evaluation of structural strength)

Subject of follow-up evaluation		Evaluation status	Generated value (N/mm^2)	Evaluation benchmark value (N/mm^2)
Unit No. 3	Runway girders	Before follow-up evaluation	24 5	325
		After follow-up evaluation	247	
Unit No. 4	Runway girders	Before follow-up evaluation	171	235
		After follow-up evaluation	172	

Note) Because loads other than the weight of the runway girders themselves are dominant in relation to the generated values for both Units No. 3 and 4, the errors had minimal impact on the generated values.

Contractor (Company A):

・At the time of the analysis (around January 2007), the formulation of documents clearly setting out the bases for input was not stipulated in in-house rules. Because of this, while materials were formulated specifying the weight and other data employed in the analysis, the members of staff responsible for the analysis did not formulate materials documenting the bases for inputs that specified the method employed to calculate vertical loads from these data.

・Because of this, the staff members responsible for conducting the analysis mistakenly confused the calculation of the combination of loads in the same direction with the calculation of the combination of horizontal seismic force and vertical seismic force, and multiplied the weight of the runway girders by the coefficient employed in these calculations (0.4).

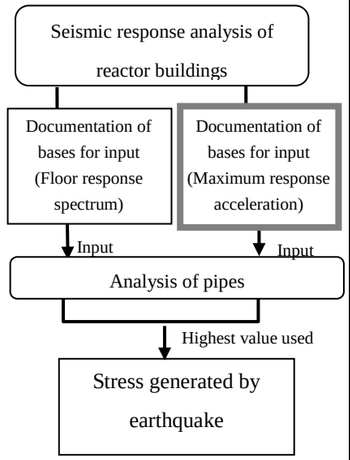
・In addition, the error was overlooked because neither the staff members responsible for conducting the analysis nor other staff members checked the method employed to calculate vertical loads.

(5)

An error was made in one case in the figure for maximum horizontal response acceleration, part of the input data used in the analysis of the pipes for the Unit No. 5 emergency diesel generator system pipes.

(Error) 1.13(G)→(Correction) 1.16(G)

The floor response spectrum and the maximum response acceleration calculated in the analysis of the seismic response of the reactor buildings was employed as input data in the analysis conducted for the pipes. Because the pipes under analysis were located on multiple stories of the building, the highest value for acceleration should have been selected for use from among the values for each story. However, due to an error, a value other than the highest value was selected.



Pipe analysis flow

・Evaluation of pipe stress employs the highest of the values for acceleration given by the maximum stress acceleration and the floor response spectrum. In the case of the pipe in question, the acceleration given by the floor response spectrum is greater than the maximum response acceleration, and there is therefore no change in the results of the evaluation of the pipe.

Affiliate (Company S), commissioned by the contractor (Company B) to perform the analysis:

・The staff members responsible for performing the analysis should have selected, from the list showing the maximum values for response acceleration for each floor of the building (two below-ground levels and five above-ground levels), the highest values for the floors on which the pipes under analysis were located (Floors 1-3). However, they mistakenly selected the value for Floor 2, rather than the value for Floor 3, which was the highest, and recorded this figure in the documentation of the bases for input. This is believed to be because the list recording the values for maximum response acceleration for each floor contained numerous similar figures, making it difficult to distinguish between them.

・With regard to verification of the validity of the bases for input, a check sheet was formulated and checks were conducted both by the members of staff responsible for conducting the analysis and other members of staff, but because the check sheet did not contain the item “Has the maximum value for the floors on which pipes are located been selected?,” the error was not discovered.

Contractor (Company B):

・Company B verified the fact that the members of staff of Company S responsible for conducting the analysis and other members of staff had checked the validity of the bases for input, but did not check the validity of the data recorded in the documentation of the bases for input.

(6)

With regard to the input data employed in simulations of changes in water levels due to the hydraulic characteristics of the water intake equipment for Units No. 3, 4 and 5, the errors shown below were made in the case of loss coefficients for the connections between intake water towers and intake tunnels and between intake tunnels and intake water ponds (two errors in the case of Unit No. 3, two in the case of Unit No. 4, and three in the case of Unit No. 5).

・Coefficients for structures of the same type that closely resembled the structures under analysis were mistakenly employed.

・Configurations are slightly different in the cases of Units No. 3 and 4, and there is therefore also a slight difference in loss coefficients. However, the figure for Unit No. 3 was used for Unit No. 4 based on the belief that they were the same.

・Key errors were made when inputting data in the formulas employed at the stage of calculations to provide bases for input.

Input data errors

Section		Details of error in relation to loss factor	
		Error	Correction
Connection between intake water tower and intake tunnel	Reverse flow side	Unit No. 5：0.613	Unit No. 5：0.664
Connection between intake tunnel and intake water pond	Forward flow side	Unit No. 3：0.343 Unit No. 4：0.365 Unit No. 5：0.525	Unit No. 3：0.348 Unit No. 4：0.369 Unit No. 5：0.528
	Reverse flow side	Unit No. 3：1.561 Unit No. 4：1.555 Unit No. 5：1.565	Unit No. 3：0.562 Unit No. 4：0.559 Unit No. 5：0.568

・Follow-up analyses using the correct data produced no major differences in results for either the side for water level increase or the side for water level decrease, demonstrating that the error had no impact on the evaluation of the seismic safety of the reactor facilities.

Results of evaluation using correct data

		Evaluation for increase in water level		Evaluation for decrease in water level	
		Maximum water level (T.P. m)	Site level (T.P. m)	Minimum water level (T.P. m)	Intake pump design minimum water level (T.P. m)
Unit No. 3	Before reevaluation	+5.05	+6.00	-5.22	-6.25
	After reevaluation	+5.05		-5.28	
Unit No. 4	Before reevaluation	+4.94	+6.00	-5.16	-6.25
	After reevaluation	+4.94		-5.22	
Unit No. 5	Before reevaluation	+5.49	+8.00	-5.33	-7.55
	After reevaluation	+5.49		-5.35	

Contractor (Company C):

・At the time of the analysis (October 2006), the formulation of materials showing the bases for inputs was not stipulated in our in-house rules. Because of this, despite the fact that the staff members responsible for conducting the analysis formulated materials recording the data employed in the analysis, they did not record sources, bases, or calculation procedures for the loss coefficients. This is believed to have led the staff members responsible for the analysis to have mistakenly used incorrect figures in the calculation of the loss coefficients in the input data, and mistakes in calculations were made due to key errors.

・In addition, the staff members responsible for conducting the analysis did not become aware of the errors because they did not conduct sufficient checks following the calculation of the incorrect loss coefficients, and data was not checked by any other members of staff.