Technical Information

Technical Consultation on Design Verification of Seismic Analysis Models considering Soil-Structure Interaction Effects for Major Structures of Non-standard Nuclear Power Plants

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[Appendix A - SCOPE OF SERVICES AND METHOD OF PERFORMANCE]

1.0 OBJECTIVES

The objectives of this technical consultation service are to provide the following services for the seismic analysis models considering Soil-Structure Interaction (SSI) effects for major structures of non-standard Nuclear Power Plants (NPPs) based on relevant regulatory and design requirements:

(1) Design verification on two major buildings of Wolsong NPP Units, 2,3 & 4
(2) Design verification on one major building of Kori NPP Units, 3,4
(3) Design verification on one major building of Hanul NPP Units, 1,2

The results of this technical consultation shall be shared with KHNP in accordance with the prime contract.

2.0 SCOPE OF WORK

To achieve the above objectives, KEPCO E&C will provide the report in Korean and seismic analysis models. The Contractor shall provide the technical consultation services to KEPCO E&C with the following tasks:

Task 1. Design verification on two major buildings of Wolsong NPP Units, 2,3 & 4

This task includes the design verification of the seismic analysis models considering SSI effects for two major buildings (Reactor building including reduced RCS model and service building) of Wolsong NPP Units, 2,3 & 4.

- Design verification on the seismic analysis models developed by KEPCO E&C

  1) FEMs (Finite Element Models) constructed based on the report provided by KEPCO E&C
     - The FEMs are constructed using beam, shell & solid elements based on the original design documents and drawings. The adequacy of the FEMs shall be verified. The FEMs will be provided including modal and fixed-base time history analysis results to check whether the FEM models are properly converted to the lumped-mass models.
     - The FEMs shall be reviewed based on the provided report by KEPCO E&C and a few general arrangement drawings for each building will also be included in the report to check whether the overall outline is properly reflected in the FEMs.

2) Lumped-mass stick models constructed based on the FEMs
   - The lumped-mass stick models to be used for SSI analyses are developed from the FEMs. The adequacy of the lumped-mass stick models shall be verified. The lumped-mass stick models will be provided including modal and fixed-base time history analysis results to check whether the FEM models are properly converted to the lumped-mass models.
3) The reasonableness of connectivity and behaviors of reduced RCS (Calandria) model included in the lumped-mass stick model of reactor building
   - The reduced RCS model is directly constructed as the lumped-mass model and shall be reviewed for the reasonableness of connectivity and behaviors.
4) SSI analysis models constructed based on the lumped-mass stick models for coherent and incoherent analysis
   - SSI analysis models are constructed based on the lumped-mass stick models. The adequacy of the SSI analysis models shall be verified. The SSI analysis models will be provided including fixed-base analysis results to check whether the SSI analysis models are properly developed from the lumped-mass stick models.

- Design verification on the adequacy of development methodologies, procedures and coherent SSI analysis results (in-structure response spectra) for the two SSI analysis models of Wolsong NPP Units, 2, 3&4
- Design verification on the adequacy of incoherent SSI analysis methodologies, procedures and results (in-structure response spectra) for the two SSI analysis models of Wolsong NPP Units, 2, 3&4
- Comments & Resolution Sheet for design verification based on Canadian regulatory and design requirements for CANDU Reactor
- Meeting minutes after technical discussion with KEPCO E&C for issues on design verification if technical discussion is required.

Task 2. Design verification on one major building of Kori NPP Units, 3,4

This task includes the design verification of the seismic analysis model considering SSI effects for one major building (Reactor building including reduced RCS model) of Kori NPP Units, 3,4.

- Design verification on the seismic analysis model developed by KEPCO E&C

1) FEM (Finite Element Model) constructed based on the report provided by KEPCO E&C

- The FEM is constructed using beam, shell & solid elements based on the original design documents and drawings. The adequacy of the FEM shall be verified. The FEM will be provided including modal and fixed-base time history analysis results to check whether the FEM is properly converted to the lumped-mass model.
- The FEM shall be reviewed based on the provided report by KEPCO E&C and a few general arrangement drawings for each building will also be included in the report to check whether the overall outline is properly reflected in the FEM.

2) Lumped-mass stick model constructed based on the FEM
   - The lumped-mass stick model to be used for SSI analysis is developed from the FEM. The adequacy of the lumped-mass stick model shall be verified. The lumped-mass stick model will be provided including modal and fixed-base time history analysis results to check whether the FEM is properly converted to the lumped-mass model.
3) The reasonableness of connectivity and behaviors of reduced RCS model included in the lumped-mass stick model of reactor building
   - The reduced RCS model is directly constructed as the lumped-mass model and shall be reviewed for the reasonableness of connectivity and behaviors.
4) SSI analysis model constructed based on the lumped-mass stick model for coherent analysis
   - SSI analysis model is constructed based on the lumped-mass stick model. The adequacy of the SSI analysis model shall be verified. The SSI analysis models will be provided including fixed-base analysis results to check whether the SSI analysis models are properly developed from the lumped-mass stick models

- Design verification on the adequacy of development methodologies, procedures and coherent SSI analysis results (in-structure response spectra) for the one SSI analysis model of Kori NPP Units, 3,4
- Comments & Resolution Sheet for design verification in accordance with U.S. NRC regulatory and design requirements for Light Water Reactor
- Meeting minutes after technical discussion with KEPCO E&C for issues on design verification if technical discussion is required

Task 3. Design verification on one major building of Hanul NPP Units, 1,2

This task includes the design verification of the seismic analysis model considering SSI effects for one major building (Reactor building including reduced RCS model) of Hanul

NPP Units, 1,2.

- Design verification on the seismic analysis model developed by KEPCO E&C
  1) FEM (Finite Element Model) constructed based on the report provided by KEPCO E&C
     - The FEM is constructed using beam, shell & solid elements based on the original design documents and drawings. The adequacy of the FEM shall be verified. The FEM will be provided including modal and fixed-base time history analysis results to check whether the FEM is properly converted to the lumped-mass model.
     - The FEM shall be reviewed based on the provided report by KEPCO E&C and a few general arrangement drawings for each building will also be included in the report to check whether the overall outline is properly reflected in the FEM.
  2) Lumped-mass stick model constructed based on the FEM
     - The lumped-mass stick model to be used for SSI analysis is developed from the FEM. The adequacy of the lumped-mass stick model shall be verified. The lumped-mass stick model will be provided including modal and fixed-base time history analysis results to check whether the FEM is properly converted to the lumped-mass model.
  3) The reasonableness of connectivity and behaviors of reduced RCS model included in the lumped-mass stick model of reactor building
     - The reduced RCS model is directly constructed as the lumped-mass model and shall be reviewed for the reasonableness of connectivity and behaviors.
  4) SSI analysis model constructed based on the lumped-mass stick model for coherent analysis
     - SSI analysis model is constructed based on the lumped-mass stick model. The adequacy of the SSI analysis model shall be verified. The SSI analysis model will be provided including fixed-base analysis results to check whether the SSI analysis model is properly developed from the lumped-mass stick model.
- Design verification on the adequacy of development methodologies, procedures and coherent SSI analysis results (in-structure response spectra) for the one SSI analysis model of Hanul NPP Units, 1,2
- Comments & Resolution Sheet for design verification in accordance with U.S. NRC regulatory and design requirements for Light Water Reactor
- Meeting minutes after technical discussion with KEPCO E&C for issues on design verification if technical discussion is required

Task 4. Kick-off and Final Meetings

- Kick-off Meeting is scheduled to be held after the Contract has been made. Details on each task and work scope are discussed.
- Final Meeting will be held after the issue of the Draft Report. Technical issues from the Draft Report are mainly discussed.
- Each Meeting is expected to last approximately 2 to 3 hours.
- Responsible manager(s) and engineer(s) shall participate in the Kick-off and Final Meetings

Task 5. Issue of design verification Report

The Draft Report in English shall be submitted to KEPCO E&C at least 1 month before the End of Service Date. Final Report incorporating review results provided by KEPCO E&C and resolutions provided by the Contractor shall be issued before the End of Service Date

3.0 METHOD OF PERFORMANCE

Consultation Schedule

The Contract period will be from the Execution Date to the March, 31, 2023(End of Service Date).

Tasks	Monthly schedule after Execution Date						
	1	2	3	4	5	6	7 (′23.03.31)
(Task 1) Design verification on two major buildings of Wolsong NPP Units, 2,3 & 4							
(Task 2) Design verification on one major building of Kori NPP Units, 3,4							
(Task 3) Design verification on one major building of Hanul NPP Units, 1,2							
(Task 4) Kick-off and Final Meetings							
(Task 5) Issue of design verification Report							

* The above schedule is subject to change with a mutual agreement

Draft Report Submittal **Final Report Submittal**

Method of Performance

- This consultation Contract shall be made under the approval of the prime contract owner.
- KEPCO E&C will provide reference documents and data so that the Contractor could perform the tasks.
- The detailed scope of work and relevant information for the tasks 1 to 3 shall be discussed and provided through the Kick-off Meeting.
- KEPCO E&C will provide review comments on the Draft Report of Task 5 submitted by the Contractor.
- The Contractor shall incorporate the review comments provided by KEPCO E&C and resolutions provided by the Contractor after the Final Meeting and subsequently submit the Final Report.

- The Kick-off and Final Meetings shall be held through a telephone or video conference.
- For task 1 to 3, if technical issues arise, telephone or video conference shall be held for technical discussion. If the technical issues are not resolved through the telephone or video conference, the Contractor shall host a resolution meeting with KEPCO E&C at the Contractor's office to discuss the encountered problems and issues.
- The costs for the technical discussion, resolution meeting and meeting minutes of Task 1 to 3 shall be included in the costs of Task 1 to 3.
- The Contractor shall keep confidential all the data and information from this Contract, and shall not divulge them to any third parties. KEPCO E&C's non-disclosure agreement shall be applied for the Contract.

Reference Documents and Data

- Seismic analysis models developed by KEPCO E&C
  - FEMs constructed using general purpose FE software (SAP2000, ANSYS, or Abaqus, etc)
  - Lumped-mass stick models constructed based on the FEMs (SAP200 or ANSYS, etc)
  - SSI analysis models for coherent and incoherent analysis (ACS SASSI)
  - The report provided by KEPCO E&C including relevant design data (i.e damping, mass, etc) for model construction
- The report describing seismic analysis model development methodologies, procedures and coherent SSI analysis results implemented by KEPCO E&C written in Korean
- The report describing incoherent SSI analysis methodologies, procedures and results implemented by KEPCO E&C written in Korean

  * The reference documents provided by KEPCO E&C will be written in Korean in compliance with the requirement of prime contract.

Deliverables

No	Task/Deliverables	schedule
1	• Comments & Resolution sheet for the design verification of Wolsong NPP Units, 2,3&4 (Task 1) • Meeting minutes after technical discussion with KEPCO E&C if technical discussion is required.	- 5 months before the End of Service Date - Within 3 weeks after the meeting

2	• Comments & Resolution sheet for the design verification of Kori NPP Units, 3, 4 (Task 2) • Meeting minutes after technical discussion with KEPCO E&C if technical discussion is required.	- 3 months before the End of Service Date - Within 3 weeks after the meeting
3	• Comments & Resolution sheet for the design verification of Hanul NPP Units, 1,2 (Task 3) • Meeting minutes after technical discussion with KEPCO E&C if technical discussion is required.	- 1 month before the End of Service Date - Within 3 weeks after the meeting
4	• Meeting minutes after the Kick-off and Final Meetings	- Kick-off Meeting: Within 3 weeks after the Meeting - Final Meeting: Before the End of Service Date
5	• Submittal of Draft Report (Task 5) • Submittal of Final Report (Task 5)	- 1 month before the End of Service Date - Before the End of Service Date

* The Drafts for Task 1 to 3 are not required.