July 20, 2009
NRC:09:076

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Response to U.S. EPR Design Certification Application RAI No. 222, Supplement 1

Ref. 1: E-mail, Getachew Tesfaye (NRC) to Ronda Pederson, et al (AREVA NP Inc.), "U.S. EPR Design Certification Application RAI No. 222 (2746, 2699,2720), FSAR Ch. 3," June 5, 2009.

2: E-mail, Ronda Pederson (AREVA NP Inc.) to Getachew Tesfaye (NRC), "Response to U.S. EPR Design Certification Application RAI No. 222, FSAR Ch 3," July 6, 2009.

In Reference 1, the NRC provided a request for additional information (RAI) regarding the U.S. EPR design certification application (i.e., RAI No. 222). In Reference 2, AREVA NP Inc. (AREVA NP) provided a response to RAI 222 and indicated that a response to Question 03.08.03-18 would be provided by July 24, 2004. The attached file, "RAI 222 Supplement 1 Response US EPR DC.pdf" provides a technically correct and complete response to that question. As indicated in the attached RAI response, enclosed is a DVD containing the files that support this RAI response.

The following table indicates the respective pages in the response document, "RAI 222 Supplement 1 Response US EPR DC.pdf" that contain AREVA NP's response to the subject questions.

Question #	Start Page	End Page
RAI 222 — 03.08.03-18	2	10

The schedule for a technically correct and complete response to the remaining questions of RAI 222 is unchanged and is provided below.

Question #	Response Date
RAI 222 — 03.04.02-8	September 11, 2009
RAI 222 — 03.04.02-9	September 11, 2009
RAI 222 — 03.06.02-20	September 11, 2009
RAI 222 — 03.06.02-21	September 11, 2009
RAI 222 — 03.06.02-22	September 11, 2009
RAI 222 — 03.06.02-23	September 11, 2009
RAI 222 — 03.06.02-24	September 11, 2009
RAI 222 — 03.06.02-25	September 11, 2009
RAI 222 — 03.06.02-26	September 11, 2009
RAI 222 — 03.06.02-27	September 11, 2009
RAI 222 — 03.06.02-28	September 11, 2009
RAI 222 — 03.06.02-29	September 11, 2009
RAI 222 — 03.06.02-31 (items 1 and 2)	September 11, 2009

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AREVA NP considers some of the material contained in the enclosure to be proprietary. As required by 10 CFR 2.390(b), an affidavit is enclosed to support the withholding of the information from public disclosure. Proprietary and non-proprietary versions of the enclosure to this letter are provided. The enclosed DVD is proprietary in its entirety.

If you have any questions related to this submittal, please contact me at 434-832-2369 or by e-mail at sandra.sloan@areva.com

Sincerely,

Sandra M. Sloan

Sandra M. Sloan, Manager
New Plants Regulatory Affairs
AREVA NP Inc.

Enclosures

cc: G. Tesfaye
Docket No. 52-020

AFFIDAVIT

COMMONWEALTH OF VIRGINIA)
) ss.
COUNTY OF CAMPBELL)

1. My name is Ronda M. Pederson. I am Licensing Manager, U.S. EPR Design Certification, Regulatory Affairs for New Plants, for AREVA NP Inc. and as such I am authorized to execute this Affidavit.

2. I am familiar with the criteria applied by AREVA NP to determine whether certain AREVA NP information is proprietary. I am familiar with the policies established by AREVA NP to ensure the proper application of these criteria.

3. I am familiar with the AREVA NP information contained in "Response to U.S. EPR Design Certification Application RAI No. 222, Supplement 1" and referred to herein as "Document." Information contained in this Document has been classified by AREVA NP as proprietary in accordance with the policies established by AREVA NP for the control and protection of proprietary and confidential information.

4. This Document contains information of a proprietary and confidential nature and is of the type customarily held in confidence by AREVA NP and not made available to the public. Based on my experience, I am aware that other companies regard information of the kind contained in this Document as proprietary and confidential.

5. This Document has been made available to the U.S. Nuclear Regulatory Commission in confidence with the request that the information contained in this Document be withheld from public disclosure. The request for withholding of proprietary information is made in accordance with 10 CFR 2.390. The information for which withholding from disclosure is

requested qualifies under 10 CFR 2.390(a)(4) "Trade secrets and commercial or financial information".

6. The following criteria are customarily applied by AREVA NP to determine whether information should be classified as proprietary:

(a) The information reveals details of AREVA NP's research and development plans and programs or their results.

(b) Use of the information by a competitor would permit the competitor to significantly reduce its expenditures, in time or resources, to design, produce, or market a similar product or service.

(c) The information includes test data or analytical techniques concerning a process, methodology, or component, the application of which results in a competitive advantage for AREVA NP.

(d) The information reveals certain distinguishing aspects of a process, methodology, or component, the exclusive use of which provides a competitive advantage for AREVA NP in product optimization or marketability.

(e) The information is vital to a competitive advantage held by AREVA NP, would be helpful to competitors to AREVA NP, and would likely cause substantial harm to the competitive position of AREVA NP.

The information in the Document is considered proprietary for the reasons set forth in paragraphs 6(b) and 6(c) above.

7. In accordance with AREVA NP's policies governing the protection and control of information, proprietary information contained in this Document has been made available, on a limited basis, to others outside AREVA NP only as required and under suitable agreement providing for nondisclosure and limited use of the information.

8. AREVA NP policy requires that proprietary information be kept in a secured file or area and distributed on a need-to-know basis.

9. The foregoing statements are true and correct to the best of my knowledge, information, and belief.

Sworn before me this 17th day of July, 2009.

Kathleen A. Bennett
NOTARY PUBLIC, COMMONWEALTH OF VIRGINIA
MY COMMISSION EXPIRES: 8/31/2011

KATHLEEN ANN BENNETT
Notary Public
Commonwealth of Virginia
118864
My Commission Expires Aug 31, 2011

Response to

Request for Additional Information No. 222, Supplement 1

6/05/2009

U. S. EPR Standard Design Certification
AREVA NP Inc.
Docket No. 52-020
SRP Section: 03.04.02 - Analysis Procedures
SRP Section: 03.06.02 - Determination of Rupture Locations and Dynamic Effects Associated with the Postulated Rupture of Piping
SRP Section: 03.08.03 - Concrete and Steel Internal Structures of Steel or Concrete Containments
Application Section: FSAR Ch. 3

QUESTIONS for Structural Engineering Branch 2 (ESBWR/ABWR Projects) (SEB2)
QUESTIONS for Engineering Mechanics Branch 2 (ESBWR/ABWR Projects) (EMB2)

Question 03.08.03-18:

During a telephone conference held on April 8, the NRC and AREVA NP agreed upon the specific data subset that would be provided to support the NRC confirmatory analysis. Accordingly, the NRC staff is requesting that AREVA NP provide the data and supporting information described below:

a) One or more DVDs containing the ANSYS (.db) and the input (.txt) files to create the ANSYS (.db) file for RBIS truncated model, including all boundary condition files. This model corresponds to the FEM model described in US EPR FSAR Section 3.8.3.4.1 and shown in Figures 3.8-32 through 3.8-37.

b) Load files for the applicable N-S or E-W direction earthquake (E and Ecommon load files) that corresponds to the soil case with the highest ZPAs (or the case with the highest shear/overturning forces) but lowest ZPA Modification Factor. AREVA will determine this and provide an explanation for the choice. A description of these files will be provided to explain their meaning and how they were developed.

c) Some of the loadings (other than the concrete elements) are represented as (a) uniform pressures (e.g., certain dead loads, percentage of live load, fluid loads, etc.) and (b) concentrated forces (e.g., for equipment). These loadings must also be accelerated by the response spectra. Consequently, these loadings must be converted to equivalent lumped masses or material densities. AREVA will either make this conversion or provide sufficient information to enable the NRC to make this conversion.

d) Accelerations in the input loading file (Item (b) above) will include the equivalent static accelerations in the selected direction with seismic modification factors included, or if separate, will so indicate. AREVA NP will explain how the equivalent static accelerations were obtained including where they were obtained. The SASSI model may not contain the same node locations as the refined static NI model with the RBIS, thus AREVA NP will explain how the seismic acceleration values from SASSI analysis are applied to the truncated RBIS model. AREVA NP will verify that these acceleration factors are the same as those used in the full NI FEM for design.

   Seismic floor response spectra (translation and rotation) in the selected governing direction (e.g., N-S and associated rotation about E-W) at the base of the RBIS model at 7 percent damping, for the soil case identified in Item (b) above. AREVA NP will indicate whether spectra correspond to the specific location at the base (bottom) of the RBIS. If not, AREVA NP will provide the spectra at the closest node beneath the base of the RBIS and the closest node above the base of the RBIS. If responses of the two spectra are not similar (i.e., within 10%) throughout the frequency range of interest, AREVA NP will interpolate between them to obtain the expected spectra at the base of the RBIS. AREVA NP will verify that floor response spectra are taken from the lumped mass stick model shown on FSAR Figure 3.7.2-3. If this is the case, AREVA NP will also provide the spectra in the reactor building containment and shield building closest to the RBIS haunch elevation. This will enable the NRC to determine the extent of any amplification from the base to the top of the haunch that may affect the overall response of the RBIS. AREVA NP will provide spectra in graphical and electronic form (e.g., Excel or text format).

e) In addition to the requested floor response spectra, AREVA NP will provide acceleration (or displacement) time histories for translation and rotation corresponding to spectra determined from Item (e) above. AREVA NP will verify that these time histories are obtained directly from the SASSI analysis building response for the soil case identified in Item (b) above.

f) RBIS responses (displacements, member forces) for representative nodal locations and structural elements covering the different elevations (top to bottom) and locations (e.g., compartments and platforms) within each elevation. These responses are expected to correspond to those obtained from the full ANSYS NI FEM that allows uplift as used in the design analysis presented in the U.S. EPR FSAR. AREVA NP will verify that these responses are the forces and displacements only from analysis of the horizontal direction selected in (b) above. Displacements will be made at more flexible locations, while member forces will be made at more rigid locations. Presentation will be created and provided in EXCEL format. Explanation will be provided for choice of locations.

g) To address potential differences in the results of the confirmatory analysis and the design basis results discussed in (g) above, AREVA NP will re-run the RBIS model provided to the NRC using the same FEM model (fixed base boundary conditions) and equivalent static loadings discussed in Items (a) and (b) above and will provide the complete set of responses (displacements, member forces) for the RBIS using the default set of such responses available in ANSYS. This will be provided in electronic form.

h) Validation of re-run analysis results using the fixed base RBIS model discussed in (h) above with the results obtained from the full NI model containing the RBIS discussed in (g) above. This will be achieved by creating additional Excel tables that compare RBIS responses from Item (h) above for the same representative locations discussed in Item (g) above. If comparison of the results of (g) and (h) show significant differences, then (g) will be performed using the full ANSYS NI FEM with fixed base conditions. In demonstration, AREVA NP will provide a representative subset of results from the full ANSYS NI FEM that allows uplift.

i) AREVA NP will state the version of ANSYS used and describe in technical terms the platform used to execute ANSYS (e.g., IBM PC Windows, bit size, and type(s) of processors) for the original design basis evaluation in the FSAR (Item (g) above) and for the re-run performed for item (h) above.

j) Information needed to understand the FEM model, loading, analytical method, and interpretation of results that is otherwise not provided in the RBIS model description currently presented in U.S. EPR FSAR, Section 3.8.3.4.1 and shown in Figure 3.8-32. The description will be in sufficient detail to minimize the need for further discussion.

Response to Question 03.08.03-18:

a) Enclosed to this response is a DVD containing the following files:

- The file Batch_Run_Create_RBIS_Fixed.txt is used to create the Reactor Building Internal Structures (RBIS) model. This file begins by resuming the database NI_GEOMETRY_ONLY.db, which contains the geometry of the full static model.
- The file Batch_Run_Create_RBIS_Fixed.txt truncates the full static model so that only the RBIS remains. The file then reads in the zero period acceleration (ZPA) and ZPA

modification factor values, which are provided in the files ZPA_values_SC01.txt and ZPA_modification_factors_SC01.txt, respectively (values are taken from soil case SC01 as per Part b of this response). The batch file applies fixed boundary conditions to nodes along the bottom of the RBIS and along the haunch walls. The black nodes shown in Figure 03.08.03-18-1 are fixed for all degrees of freedom by calling the subroutine Boundary_Conditions_RBIS_Fixed.txt.

- Batch_Run_Create_RBIS_Fixed.txt saves the RBIS model as Fixed_RBIS.db.

b) The smallest horizontal modification factor is 0.65 for soil case SC01 in the x (east-west) direction. Soil case SC01 also results in the highest ZPAs at numerous elevations in the RBIS (see U.S. EPR FSAR Tier 2, Table 3.7.2-10).

The east, west, and common seismic load files (see files E_E.txt, E_W.txt, and E_common.txt, respectively in the enclosed DVD) as well as the dead, live, and hydrostatic pressure load files (D.txt, L.txt, and F.txt, respectively in the enclosed DVD), which were developed for the full static model, are truncated to contain only commands relevant to the RBIS. The phrase '_RBISonly' is appended to the title of each load file (for example, the truncated version of D.txt is entitled D_RBISonly.txt) in order to differentiate the new load files from the original ones.

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c) Many of the dead (D), live (L), and hydrostatic pressure (F) loads contained in the files described above are applied as concentrated forces or uniform pressures. While this is acceptable for a static analysis, a response spectrum analysis requires that these loads be converted to equivalent lumped masses. The file batch_mass_calc.txt was created to perform this conversion and is provided in the enclosed DVD.

The file batch_mass_calc.txt resumes the Fixed_RBIS.db database, reads the load files D_RBISonly.txt, L_RBISonly.txt, and F_RBISonly.txt, and then utilizes the script file mass_calc.txt to convert the point and pressure loads to masses. The fixed base RBIS model with dead, live, and hydrostatic pressure loads (only vertical hydrostatic pressure loads are converted, see Part k of this response) represented as masses is then saved as Fixed_RBIS_Masses.db.

d) The SASSI stick model (described in U.S. EPR FSAR, Tier 2, Section 3.7.2) contains lumped nodes (mass, rigidity, etc.) at every major floor elevation. These nodes are based on properties from half a story below a given floor to half a story above the floor.

The maximum ZPA at each major floor elevation in the RBIS is obtained from the SASSI model, and these values are stored in an array as part of the RBIS model described in Part a of this response. The seismic load files described in Part b of this response apply these ZPAs to the nodes in the RBIS. For nodes in the RBIS that lie in between major floor elevations, ZPAs are applied from the nearest major floor elevation above the node.

The preceding methodology is conservative for two reasons: 1). At each elevation, the maximum ZPA from the SASSI model is applied to all relevant nodes in the finite element model (FEM), and 2) ZPAs tend to increase with increasing elevation, and nodes that lie in between major floor elevations receive a ZPA value that is based on a higher elevation. ZPA modification factors are included for some soil cases (including soil case SC01) in order to reduce the amount of conservatism. Modification factors are stored as parameters in the RBIS model described in Part a of this response and they are applied whenever ZPAs are applied (i.e. [Seismic Acceleration] = [ZPA value] X [ZPA Modification Factor]).

The ZPA values and ZPA modification factors used in the RBIS model are the same as those used in the full Nuclear Island (NI) static model used for design.

e) The translational (x-direction) and rotational (about the y and z-axes) seismic floor response spectra associated with the x-direction at 7 percent damping are provided in the Excel file, ResponseSpectra.xls, provided in the enclosed DVD. Response spectra are provided in tabular form in the first worksheet and in graphical form in the subsequent worksheets.

Response spectra are provided from the SASSI lumped mass stick model at nodes 1008 (Elevation -8.6m) and 1009 (Elevation -6.15m). The base of the RBIS is at Elevation -7.80m. Node 1008 is the nearest node beneath the base of the RBIS and node 1009 is the nearest node above the base of the RBIS. Table 03.08.03-18-1 lists the percent difference between the translational response spectra at nodes 1008 and 1009. The response spectra in the x-direction are seen to be nearly identical (within 0.1 percent).

The peak rotational response spectra acceleration about the y-axis is 0.000387 g-rad/m, which occurs at a frequency of 4.4 Hz at node 1009. The height of the RBIS is approximately 42.5 m, and so the maximum horizontal acceleration due to rotation about the y-axis is 0.000387*42.5 m = 0.016 g.

The peak rotational response spectra acceleration about the z-axis is 0.000239 g-rad/m, which occurs at a frequency of 14.0 Hz at node 1009. The radius of the RBIS is approximately 23.4 m, and so the maximum acceleration due to rotation about the z-axis is 0.000239*23.4 = 0.0056 g.

The rotational response spectra are considered to be negligible when compared with the translational response spectrum. This is expected since soil case SC01 represents hard rock.

To perform a response spectrum analysis of the RBIS in the x-direction, it is therefore sufficient to consider the input motion at the base of the RBIS to be the x-direction response spectrum listed in ResponseSpectra.xls (taken from either node 1008 or 1009, since the two spectra are virtually identical). The rotational spectra can be neglected.

Figure 03.08.03-18-2 shows a schematic of the SSI stick model, which details the connectivity of the NI structures with the basemat. Note that nodes 1008 and 1009 are connected via rigid links to the bottoms of the RBIS, containment, and shield building sticks. Therefore, the time histories (and corresponding response spectra) at nodes 1008 and 1009 take into account any amplification from the containment and shield building sticks that may be exerted on the RBIS through the haunch wall.

f) The absolute translational and rotational acceleration time histories at nodes 1008 (Elev. -8.60m) and 1009 (Elev. -6.15m) of the SASSI analysis building response (soil case SC01 is used as discussed in Part b of this response) are provided in the files TimeHistory_1008.txt (node 1008) and TimeHistory_1009.txt (node 1009) in the enclosed DVD.

g) RBIS responses for representative node locations and structural elements are provided in the Excel file, ModelComparison.xls, in the enclosed DVD. These responses correspond to an analysis of eastward seismic loading only. East seismic loading was chosen to correspond with the x direction, which was selected in Part b of the response. The analysis was not repeated for westward loading since similar results are expected. RBIS responses listed as 'Full Nonlinear' correspond to those obtained from the full ANSYS NI static model that allows uplift as used in design analysis presented in the U.S. EPR FSAR Tier 2, Section 3.8.3.4.1 and shown in Figures 3.8-32 through 3.8-37. Because this model allows uplift, it can not be directly analyzed for east seismic loading only. With no dead loads, the model fully uplifts and will not reach static equilibrium. Instead, a two step process is used to approximate an analysis of east seismic loading only. First, the model is solved under dead loading only. Next, the model is solved for dead plus east seismic loading. Results from dead loading are then subtracted from the results from dead plus seismic loading to obtain (approximately, since the model is nonlinear) results from east seismic loading only.

Nodes and members were selected for post-processing at different elevations covering the full height of the RBIS. Nodes where chosen at locations where large amounts of displacement are expected to occur, such as at the unsupported areas of walls. Nodes were also chosen to be in a variety of areas/compartments of the RBIS. Members were

chosen where forces are expected to be high. Members were selected that are approximately perpendicular to the seismic direction and near the outer radius of the RBIS on opposite sides.

h) The RBIS model, Fixed_RBIS.db, which is described in Part a of this response, is analyzed for the eastward seismic loading as described in Part b of this response. The complete set of results is contained in the ANSYS results file, EastSeismicResponseofRBIS.rst, in the enclosed DVD.

i) RBIS responses for representative node locations and structural elements are provided in tabular and graphical form in the Excel file, ModelComparison.xls, (provided in the enclosed DVD) for three different models. Responses listed as 'Full Nonlinear' correspond to those obtained from the full ANSYS NI static model that allows uplift (Part g of this response), while responses listed as 'Full Fixed' are obtained from the full ANSYS NI static model with fixed base conditions. Responses listed as 'RBIS' are obtained from the fixed base RBIS-only model discussed in Part h of this response.

   The worksheet 'NonlinearNI vs RBIS' provides the percent difference between the RBIS model and the full nonlinear model, while the worksheet 'FixedNI vs RBIS' provides the percent difference between the RBIS model and the full fixed base model. The other worksheets in the Excel file plot representative nodal and member results (x displacements, z displacements, y rotations, and all member forces and moments).

j) ANSYS was performed using ANSYS version 10, service pack 1 running on Windows XP Professional x64 Edition (64 bit). The original design basis evaluation in the U.S. EPR FSAR was performed using Dell Precision PWS690 Intel Xeon CPU 5120 at 1.86 GHz, 3.00 GHz, or 3.73 GHz. The re-run performed for Part h of the response and the post-processing of the original results files were performed using Dell Precision T7400 Intel Xeon CPU X5450 at 3.00GHz.

k) The information needed to understand the FEM model, loading, and analytical method is described in Parts a through j of this response. When interpreting results from analyses that utilize the mass conversion methodology described in Part c of this response, it should be noted that the file mass_calc.txt in the enclosed DVD (see Part c of this response) converts only vertical hydrostatic loadings to an equivalent mass. Lateral hydrostatic loads are neglected since these loads are not readily adapted to be modeled by an equivalent mass. Any corresponding lateral hydrodynamic loads will also be neglected. When this methodology is employed, results in the vicinity of pool walls may not be accurate. The effect away from pool walls is expected to be negligible.

FSAR Impact:

The U.S. EPR FSAR will not be changed as a result of this question.

Table 03.08.03-18-1—Percent Difference between Translational Response Spectra at Nodes 1008 and Node 1009

Frequency (Hz)	Percent Difference
0.2000	0.00%
0.3000	0.00%
0.4000	0.00%
0.5000	0.00%
0.6000	0.00%
0.7000	0.00%
0.8000	0.00%
0.9000	0.00%
1.0000	0.01%
1.1000	0.00%
1.2000	0.00%
1.3000	0.00%
1.4000	0.01%
1.5000	0.00%
1.6000	0.01%
1.7000	0.01%
1.8000	0.01%
1.9000	0.02%
2.0000	0.01%
2.1000	0.00%
2.2000	0.02%
2.3000	0.02%
2.4000	0.02%
2.5000	0.03%
2.6000	0.02%
2.7000	0.04%
2.8000	0.04%
2.9000	0.01%
3.0000	0.01%
3.1500	0.04%
3.3000	0.03%
3.4500	0.03%
3.6000	0.02%
3.8000	0.06%
4.0000	0.06%
4.2000	0.05%
4.4000	0.02%
4.6000	-0.03%
4.8000	-0.03%
5.0000	-0.02%
5.2500	-0.03%
5.5000	-0.03%
5.7500	-0.03%
6.0000	-0.05%
6.2500	-0.06%
6.5000	-0.06%
6.7500	-0.07%
7.0000	-0.06%
7.2500	-0.05%
7.5000	-0.06%
7.7500	-0.06%
8.0000	-0.05%
8.5000	-0.05%
9.0000	-0.05%
9.5000	-0.05%
10.0000	-0.06%
10.5000	-0.05%
11.0000	-0.06%
11.5000	-0.06%
12.0000	-0.06%
12.5000	-0.04%
13.0000	-0.04%
13.5000	-0.04%
14.0000	-0.01%
14.5000	-0.01%
15.0000	-0.01%
16.0000	-0.03%
17.0000	-0.01%
18.0000	0.00%
20.0000	0.01%
22.0000	-0.01%
25.0000	-0.02%
28.0000	-0.02%
31.0000	-0.05%
34.0000	-0.04%
50.0000	-0.03%
100.0000	-0.04%

Figure 03.08.03-18-1—Wireframe View of the RBIS Model Illustrating the Fixed Boundary Condition Nodes (Highlighted in Black)

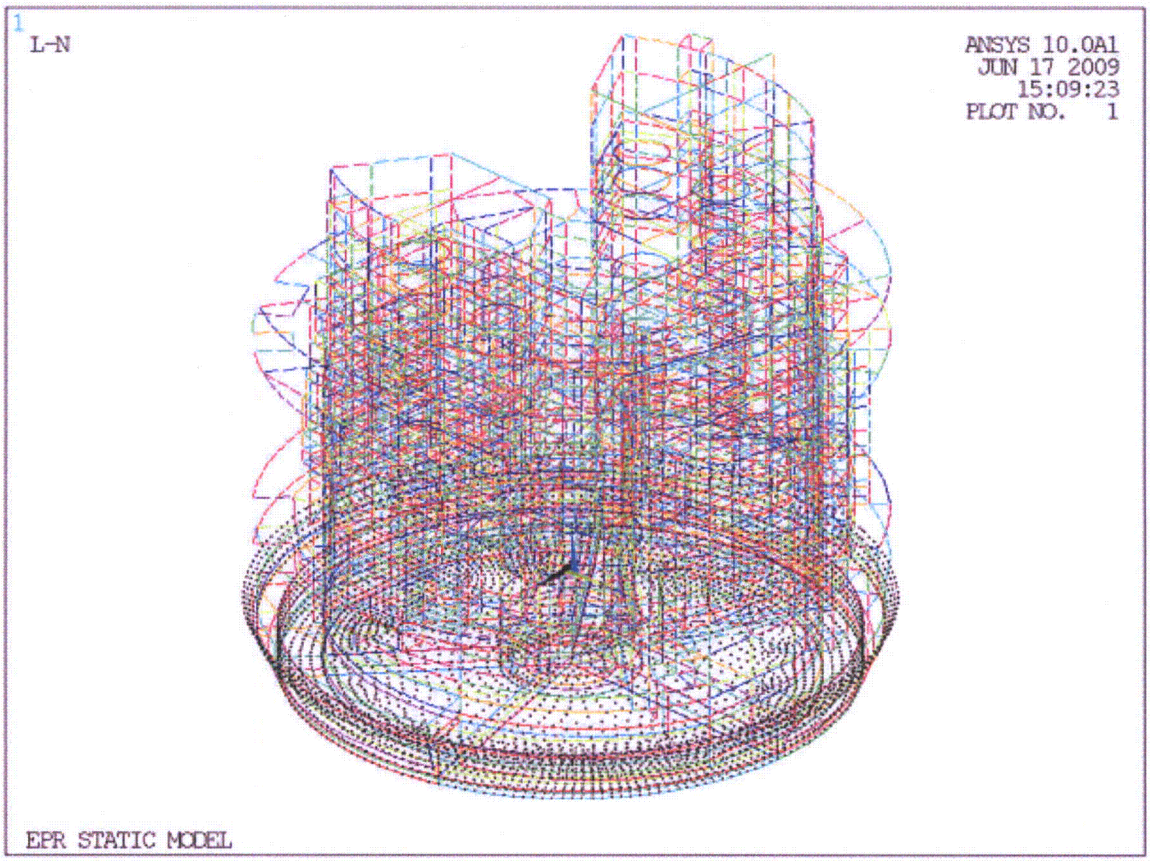
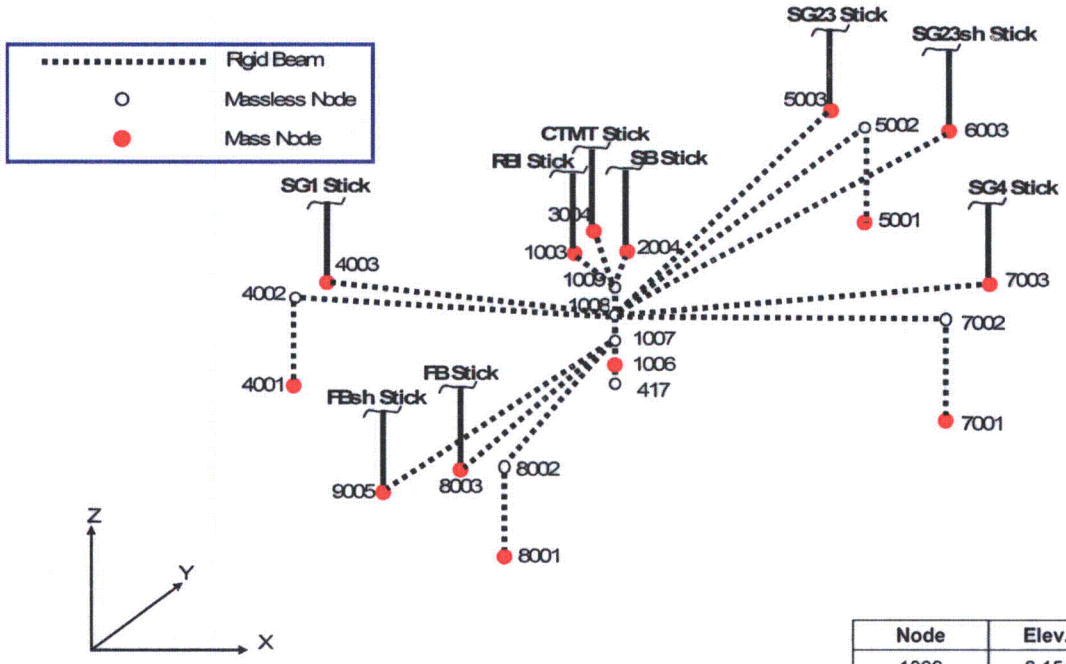


Figure 03.08.03-18-2—Connectivity of NI Structures with Stick Model of Basemat



Node	Elev.
1009	-6.15m
1008	-8.60m
1007	-9.60m
1006	-11.10m
417	-11.85m
4001 5001 7001 8001	-12.60m