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UniStar
NUCLEAR ENERGY

10 CFR 50.4
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September 15, 2011

UN#11-251

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Subject: UniStar Nuclear Energy, NRC Docket No. 52-016
Response to Request for Additional Information for the Calvert Cliffs Nuclear Power Plant, Unit 3, RAI No. 304, Seismic System Analysis

Reference:
1) Surinder Arora (NRC) to Robert Poche (UniStar Nuclear Energy), "FINAL RAI 304 SEB2 5717, dated May 11, 2011.

2) UniStar Nuclear Energy Letter UN#11-240, from Greg Gibson to Document Control Desk, U.S. NRC, Calvert Cliffs Nuclear Power Plant, Unit 3 RAI Closure Plan, dated August 23, 2011.

The purpose of this letter is to respond to the request for additional information (RAI) identified in the NRC e-mail correspondence to UniStar Nuclear Energy, dated May 11, 2011 (Reference 1). This RAI addresses Seismic System Analysis, as discussed in Section 3.7 of the Final Safety Analysis Report (FSAR), as submitted in Part 2 of the Calvert Cliffs Nuclear Power Plant (CCNPP) Unit 3 Combined License Application (COLA), Revision 7.

A schedule for the response to RAI 304 Question 03.07.02-54 was provided in Reference 2. The enclosure provides our response to RAI No. 304 Question 03.07.02-54.

Our response does not include any new regulatory commitments. This letter does not contain any sensitive or proprietary information.

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NRO

If there are any questions regarding this transmittal, please contact me at (410) 470-4205, or Mr. Wayne A. Massie at (410) 470-5503.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on September 15, 2011

Greg Gibson

Enclosure: Response to NRC Request for Additional Information RAI No. 304, Question 03.07.02-54, Seismic System Analysis, Calvert Cliffs Nuclear Power Plant, Unit 3

cc: Surinder Arora, NRC Project Manager, U.S. EPR Projects Branch
Laura Quinn, NRC Environmental Project Manager, U.S. EPR COL Application
Getachew Tesfaye, NRC Project Manager, U.S. EPR DC Application (w/o enclosure)
Charles Casto, Deputy Regional Administrator, NRC Region II (w/o enclosure)
Silas Kennedy, U.S. NRC Resident Inspector, CCNPP, Units 1 and 2
U.S. NRC Region I Office

GTG/AJF/mdf

Enclosure

Response to NRC Request for Additional Information
RAI No. 304, Question 03.07.02-54,
Seismic System Analysis,
Calvert Cliffs Nuclear Power Plant, Unit 3

RAI No. 304

Question 03.07.02-54

In Question 03.07.02-42, the staff asked the applicant to demonstrate that the structural model was sufficiently detailed such that further refinement would have a negligible effect on the analysis results (see SRP 3.7.2, Acceptance Criteria 3.C.ii) and to demonstrate that the SSI modeling of the soil was sufficiently detailed such that the frequency range of interest of the earthquake time history input to the structure was not limited by the size of the finite elements used to model the soil (see SRP 3.7.1, Structural Acceptance Criteria 4.A.vii). In its response, the applicant provided a basis for the mesh size of the soil in the vertical direction. This was based on the lower bound soil properties of Table 3F-7 and a requirement to capture the earthquake input up to a frequency of 50 Hz. However, any limitations or requirements for the mesh sizes in the horizontal direction which are shown in Figure 3.7.2-27 were not described nor was the vertical mesh size defined for elevations below elevation -27.5 feet. In addition, on page 12 of Enclosure 2 it states the mesh size in the vertical direction is 1.6 feet, not the 1.5 feet provided in the applicant's response. Because the information provided only addresses the mesh size in the vertical direction above elevation -27.5 feet, and does not address whether the structural model is sufficiently detailed, the applicant is requested to provide the following additional information in order for the staff to conclude that the structure and the soil models are sufficiently refined and meet the SRP criteria mentioned above:

1. Provide for the horizontal directions the soil model mesh size for elevations both above and below elevation -27.5 feet and their technical basis.

2. Provide the basis for the mesh size in the vertical direction below elevation -27.5 feet.

3. Resolve the discrepancy between the mesh size of 1.5 feet and 1.6 feet.

4. Demonstrate, as originally requested, whether the dynamic structural model is sufficiently detailed such that further refinement will have a negligible effect on the solution results.

Response

Question Part 1:

The Common Basemat Intake Structures (CBIS) at Calvert Cliffs Nuclear Power Plant (CCNPP) Unit 3 include the Makeup Water Intake Structure (MWIS), the Forebay, and the Circulating Water Makeup Intake Structure (CWIS). Previously, a Seismic Soil Structure Interaction (SSI) analysis was performed on the CBIS to evaluate the seismic response of the structures using a model that included only the western half of the CBIS, as shown in Figure 1. RIZZO's SASSI program version 1.3a is used for the SSI analysis.

The mesh used for the excavated soil in the SSI analysis of the western half of the CBIS is shown in Figure 2. The soil layer thickness (soil mesh density considered in the vertical direction) is based on the wave propagation requirement to ensure that a 50 Hz cut off frequency is captured. This is described in detail in the response to Question Part 2 of this RAI. The SSI analysis using SASSI requires the CBIS structural nodes below ground level to be

located at the positions of the soil layer interfaces. Hence, the mesh size in the vertical direction for the structural elements (Figure 1) is equal to the adjacent soil layer thicknesses (Figure 2).

The SSI model of the CBIS uses a relatively fine mesh in the MWIS area, while the mesh in the Forebay and CWIS areas is relatively coarse, as shown in Figure 1 and Figure 2. The mesh used for the excavated soil is based on an aspect ratio of about 3.5 and 4.0 in plan in the MWIS and Forebay regions, respectively. The aspect ratio referred to here is the ratio of maximum to the minimum dimension of a solid element.

A sensitivity analysis is performed in order to evaluate the effect of additional refinement of the mesh used for the excavated soil. The mesh is held constant in the vertical direction (thickness of soil layers) because it is deemed to satisfy the vertical wave propagation requirement that ensures that a 50 Hz cut off frequency is captured.

A quarter of the Forebay area is considered for the sensitivity analysis. Region ABCDEF in Figure 2 shows the portion of the Forebeay area considered in the sensitivity analysis. Figure 3 shows a quarter model of the Forebay having 1386 solid elements, and it represents a similar mesh to the one used in the SSI analysis of the complete CBIS model shown in Figure 1 and Figure 2. A refined quarter model of the Forebay region is created as shown in Figure 4 in order to assess the effect of further mesh refinement. The refinement is performed so that each solid element of the coarse mesh model in Figure 3 is subdivided into four solid elements in plan, and the resulting refined model, shown in Figure 4, consists of 5544 solid elements. The excavated soil mesh in the plan direction doesn't depend on depth and is uniform from the ground surface (Elevation 10 ft) to the depth of the foundation (Elevation. -27.5 ft).

Moreover, two symmetric planes are introduced in these models, one in the North-South direction and the other in the East-West direction as shown in Figure 3 and 4. Introducing these two planes of symmetry in the models, effectively extends the sensitivity study to cover a region that encloses the full size of the Forebay region. Hence, the results obtained from this model are deemed to represent the results that would be obtained if a complete model of the CBIS is considered.

SSI analyses are performed on the fine and coarse mesh models (see Figure 3 and 4) for input motions in the X, Y and Z directions. The SSI analysis performed for the sensitivity analysis is similar to that carried out for the full model of the CBIS, but only the best estimate soil condition is considered. Similar to the full model of the CBIS, the ground surface for the sensitivity analysis models is retained at Elevation 10.0'. The Basemat and Forebay walls are included in the models with 5' and 4.5' thicknesses, respectively.

In-structure response spectra (ISRS) are computed at three locations from the results yielded by the SSI analyses:

1. On the Basemat floor. Average ISRS are computed for the Basemat floor using the results obtained at the 5 locations marked in red in Figure 5 (floor EFGH).
2. On top of the West side Forebay wall. Average ISRS are computed on top of the West side Forebay wall using the results obtained at the three (3) locations marked in blue in Figure 5 (wall CDEF).
3. On top of the North side Forebay wall. Average ISRS are computed on top of North side Forebay wall using the results obtained at the three (3) locations marked in yellow in Figure 5 (wall ADFG).

The ISRS are computed in the X, Y, and Z directions at the selected locations identified above, and these are plotted in Figure 6 through Figure 14 for the coarse and fine mesh models.

The ISRS presented in Figure 6 through Figure 14 demonstrate that the results yielded by a coarse mesh in the Forebay area (having an aspect ratio of approximately 4.0) are similar to those obtained from a fine mesh (having an aspect ratio of approximately 2.0). These results confirm further soil mesh refinement does not impact the outcome of the analysis, and therefore, the selected mesh refinement is adequate.

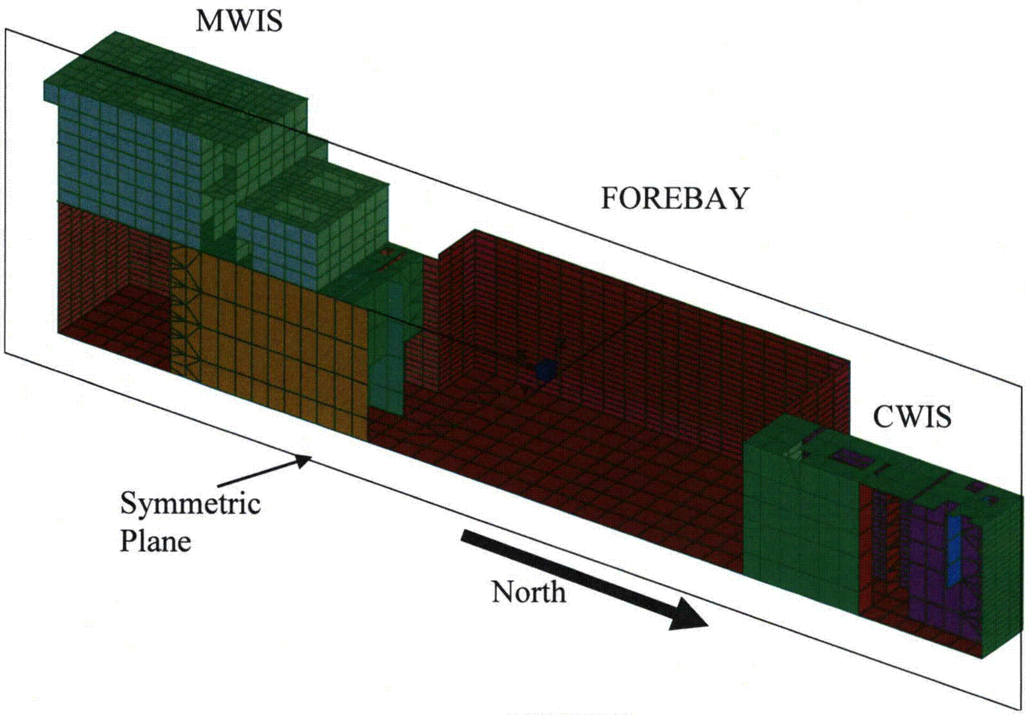


FIGURE 1.
WEST-HALF MODEL OF THE CBIS

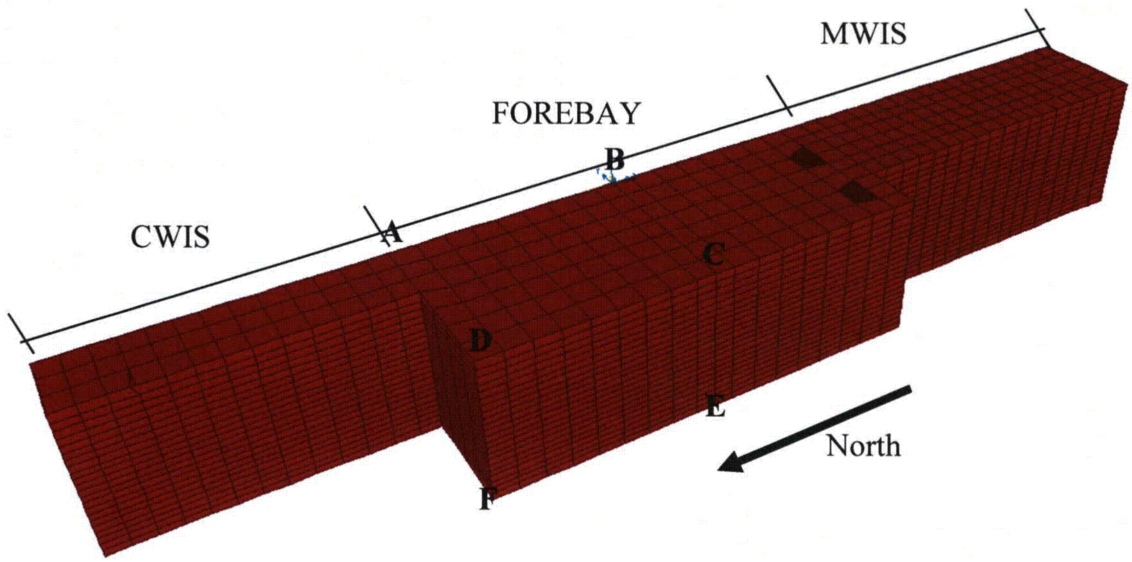
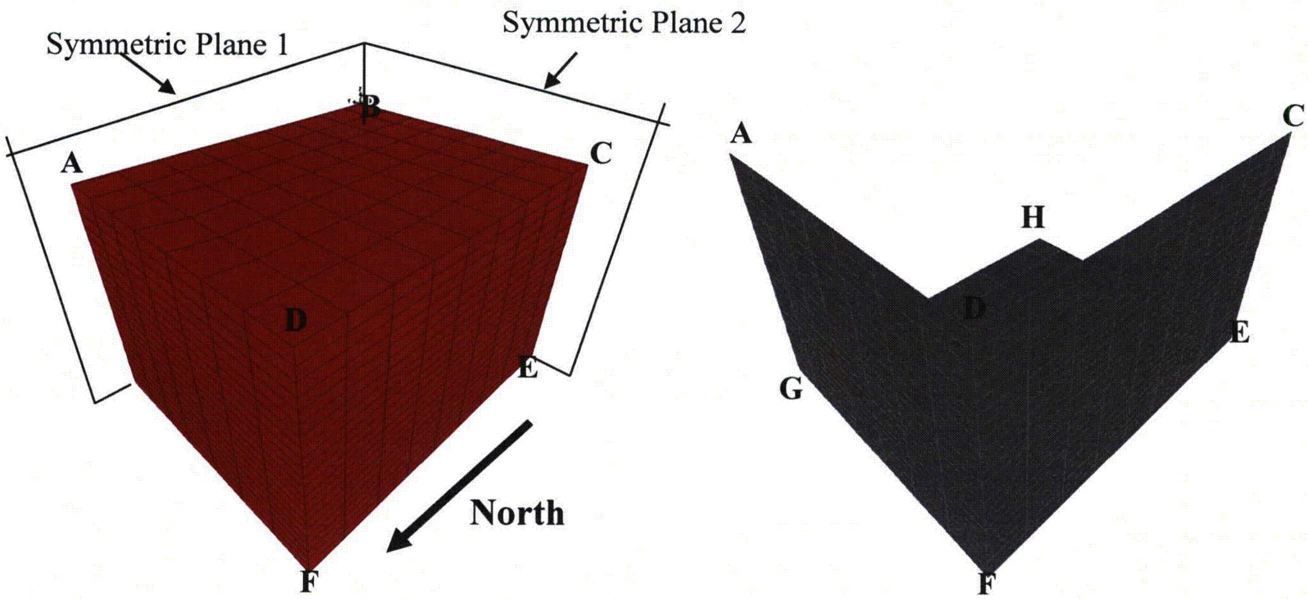


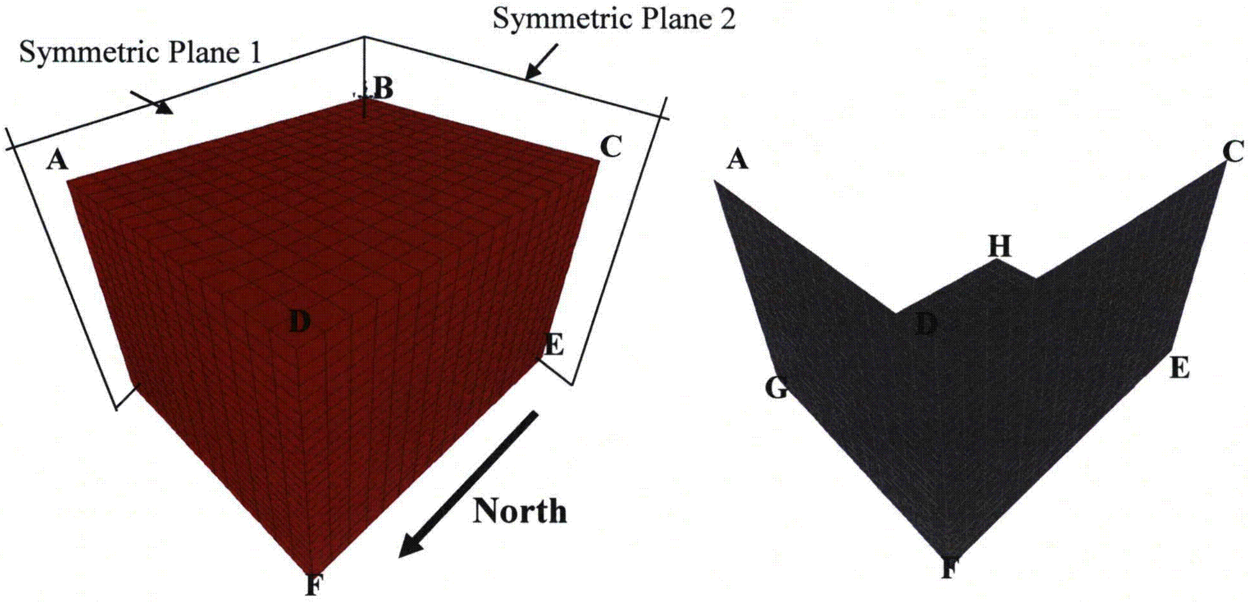
FIGURE 2.
EXCAVATED SOIL MESH CONSIDERED SSI ANALYSIS OF THE WESTERN HALF OF THE CBIS



a) Coarse soil mesh 1

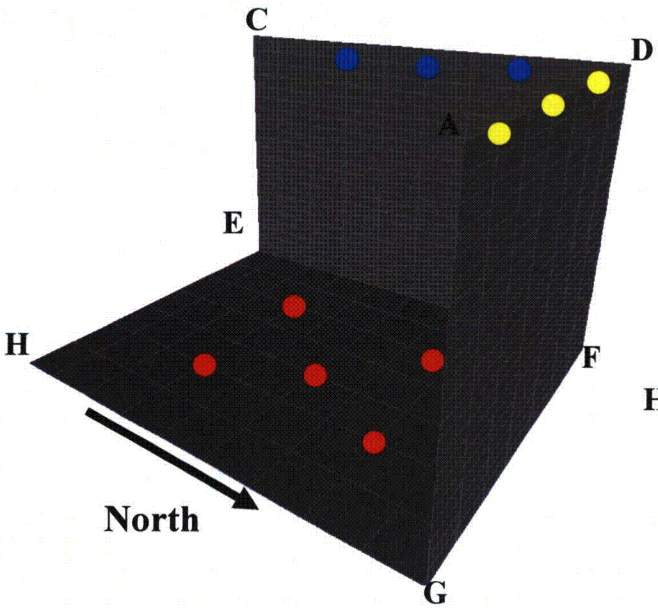
b) Coarse mesh for Basemat and Forebay Walls

FIGURE 3.
COARSE FINITE ELEMENT MODEL OF THE SOIL IN THE FOREBAY AREA WITH 1386 SOLID ELEMENTS INCLUDING THE ADJACENT BASEMAT AND FOREBAY WALLS

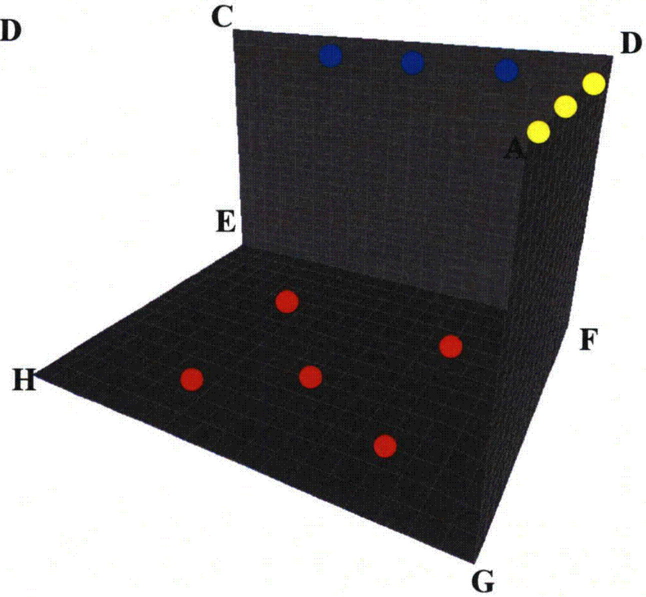


a) Refined soil mesh b) Fine mesh for Basemat and Forebay Walls

FIGURE 4.
REFINED FINITE ELEMENT MODEL OF THE SOIL MESH IN THE FOREBAY AREA WITH 5544 SOLID ELEMENTS INCLUDING THE ADJACENT BASEMAT AND FOREBAY WALLS



a) Coarse mesh Basemat and Forebay walls



b) Fine mesh Basemat and Forebay walls

FIGURE 5.
ISRS LOCATIONS ON THE BASEMAT FLOOR AND TOP OF THE FOREBAY WALLS

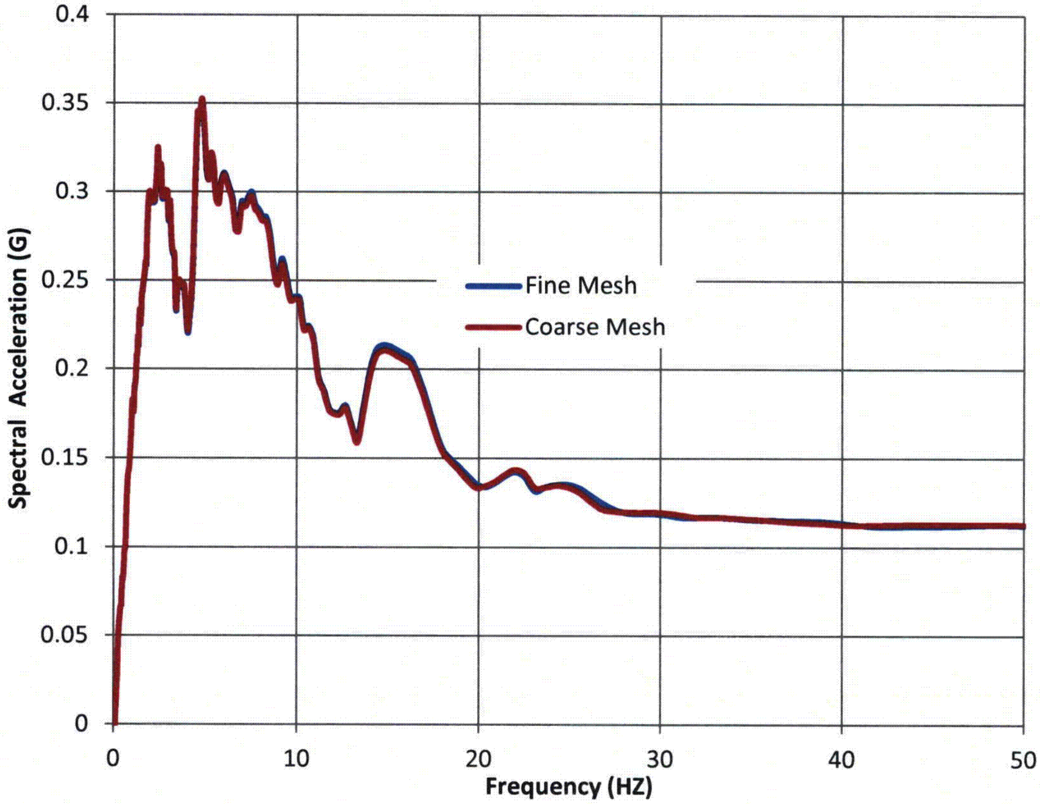


FIGURE 6.
ISRS IN THE X (NS) DIRECTION ON THE BASEMAT
(FLOOR EFGH IN FIGURE 5)

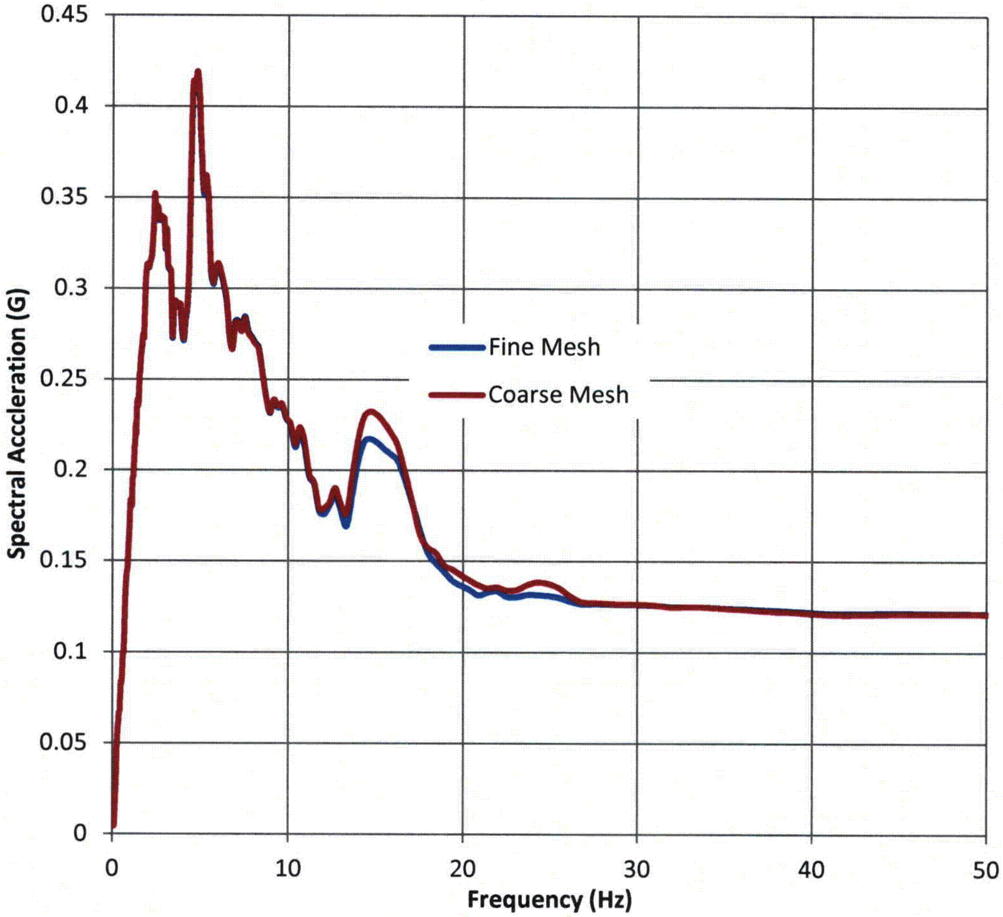


FIGURE 7.
ISRS IN THE X (NS) DIRECTION ON TOP OF THE WEST SIDE FOREBAY WALL (WALL CDFE IN FIGURE 5)

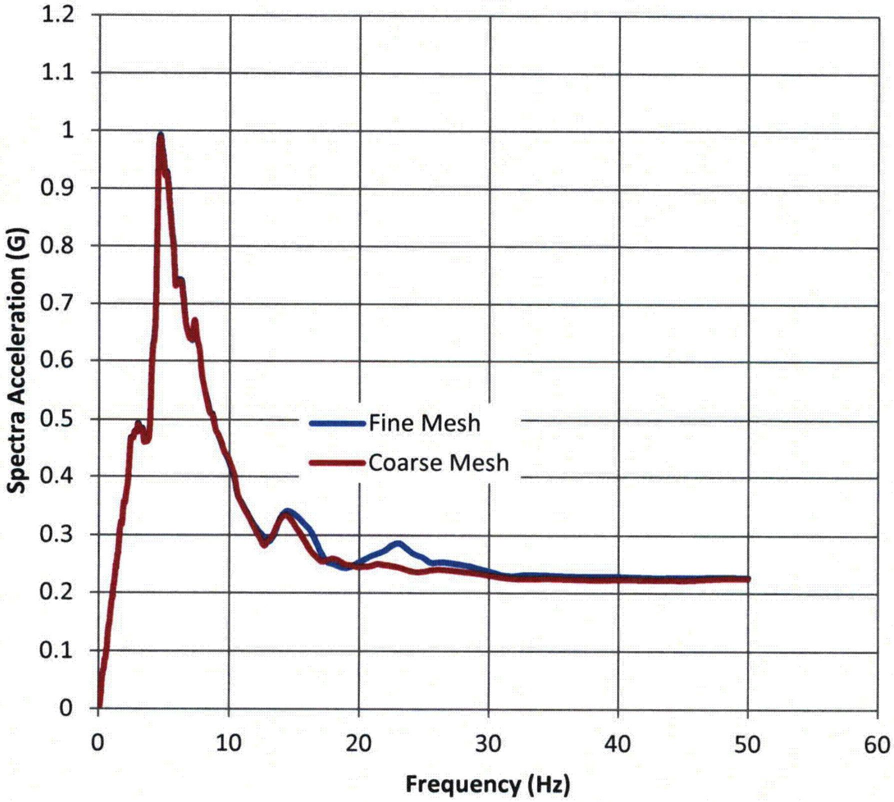


FIGURE 8.
ISRS IN THE X (NS) DIRECTION ON TOP OF THE NORTH SIDE FOREBAY WALL (WALL ADFG IN FIGURE 5)

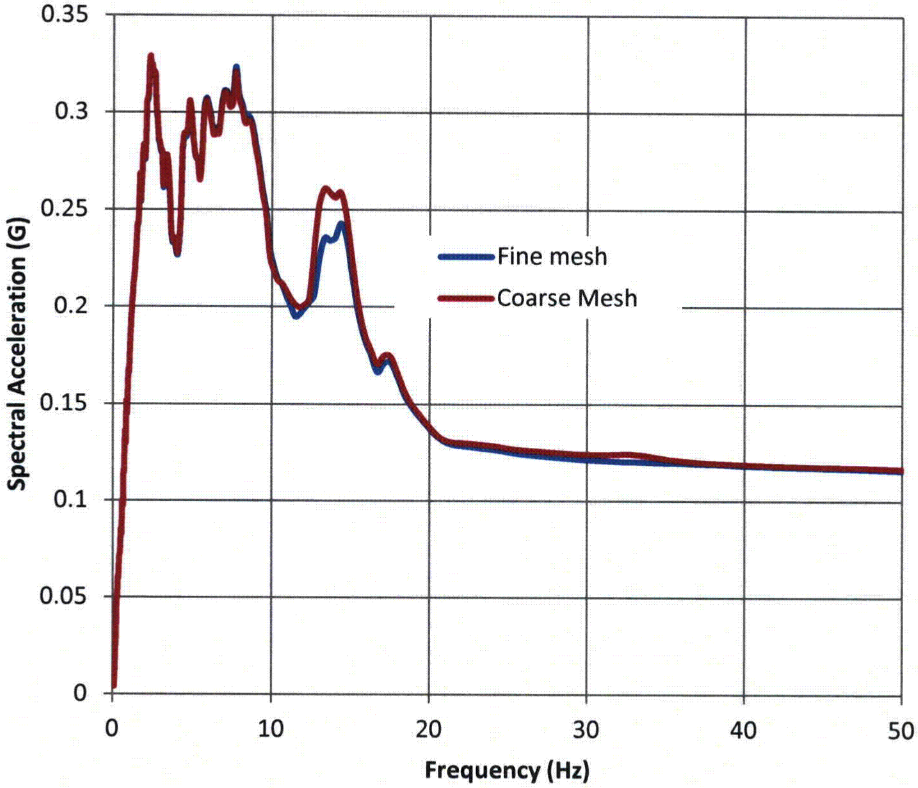


FIGURE 9.
ISRS IN THE Y (EW) DIRECTION ON THE BASEMAT
(FLOOR EFGH IN FIGURE 5)

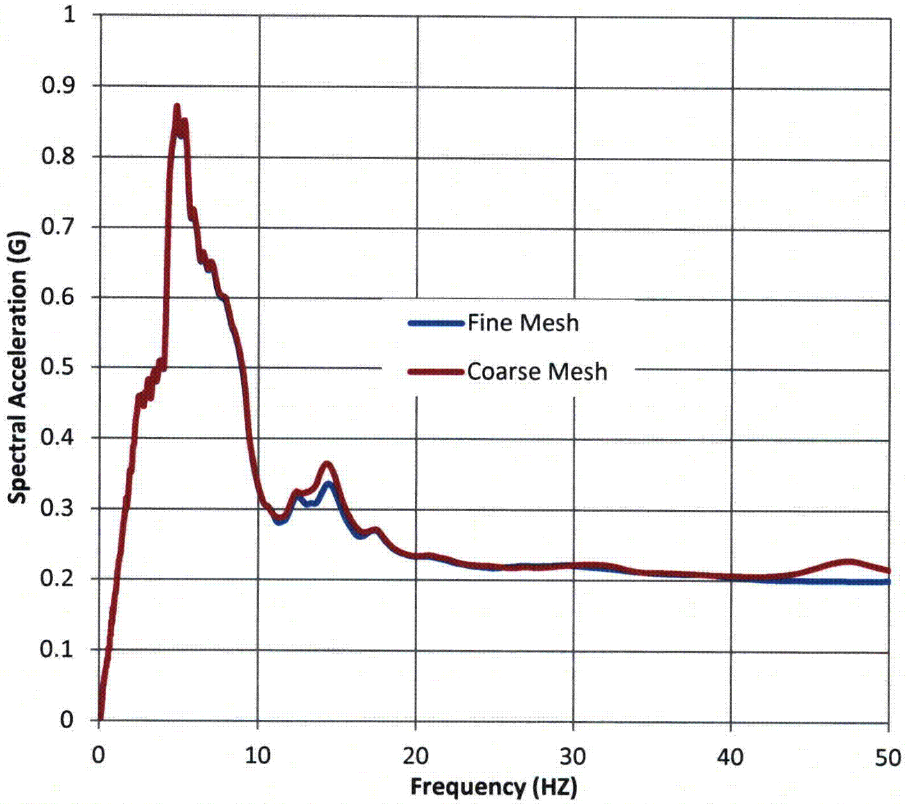


FIGURE 10.
ISRS IN THE Y (EW) DIRECTION ON TOP OF THE WEST SIDE FOREBAY WALL (WALL CDFE IN FIGURE 5)

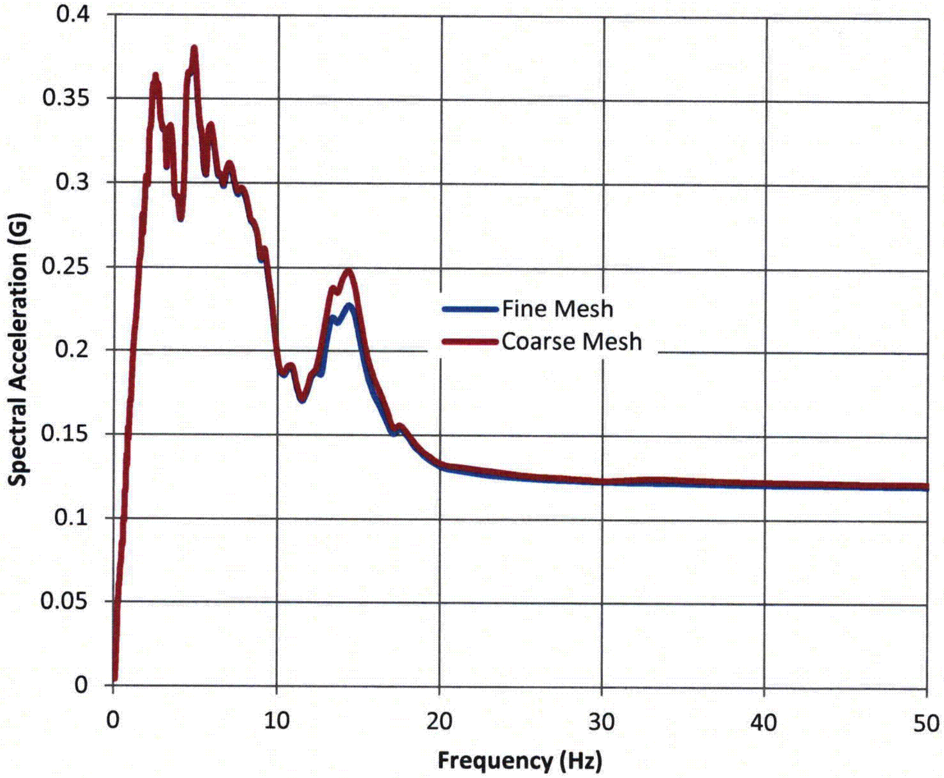


FIGURE 11.
ISRS IN THE Y (EW) DIRECTION ON TOP OF THE NORTH SIDE FOREBAY WALL (WALL ADFG IN FIGURE 5)

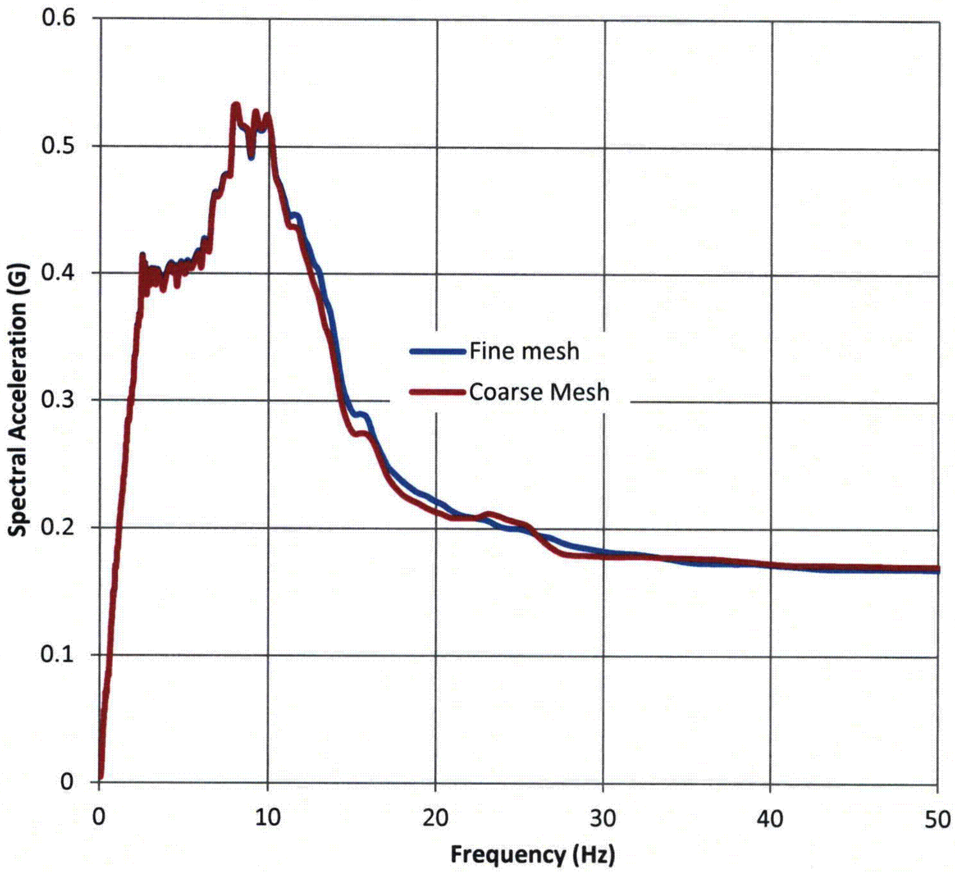


FIGURE 12.
ISRS IN THE Z (VERTICAL) DIRECTION ON THE BASEMAT (WALL EFGH IN FIGURE 5)

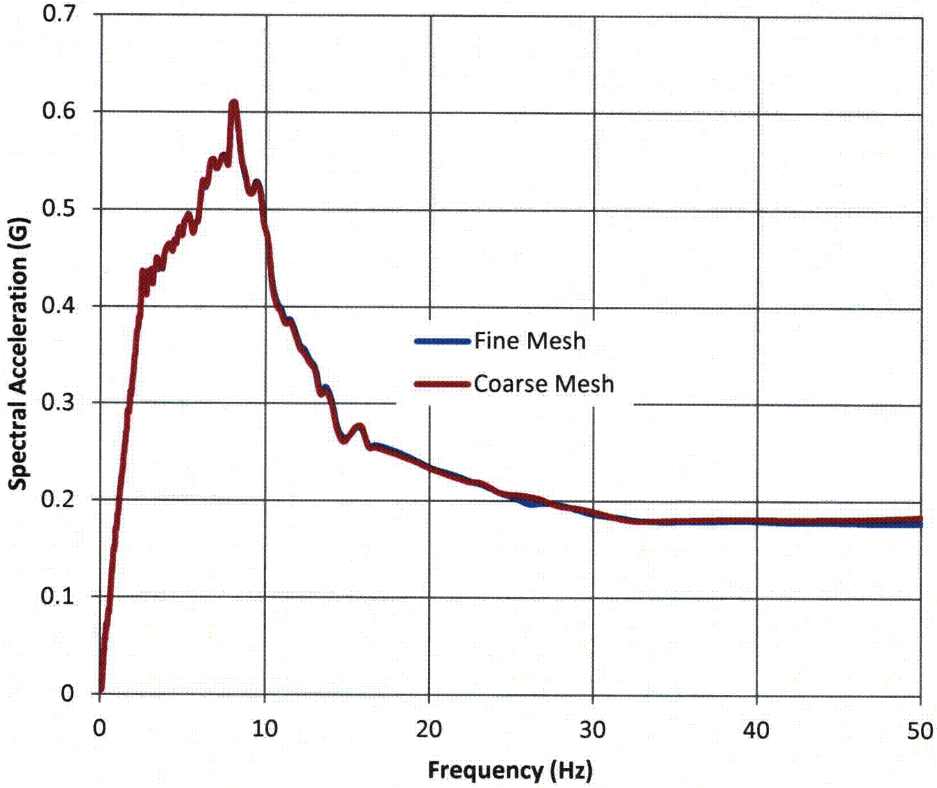


FIGURE 13.
ISRS IN THE Z (VERTICAL) DIRECTION ON TOP OF THE WEST SIDE FOREBAY WALL (WALL CDFE IN FIGURE 5)

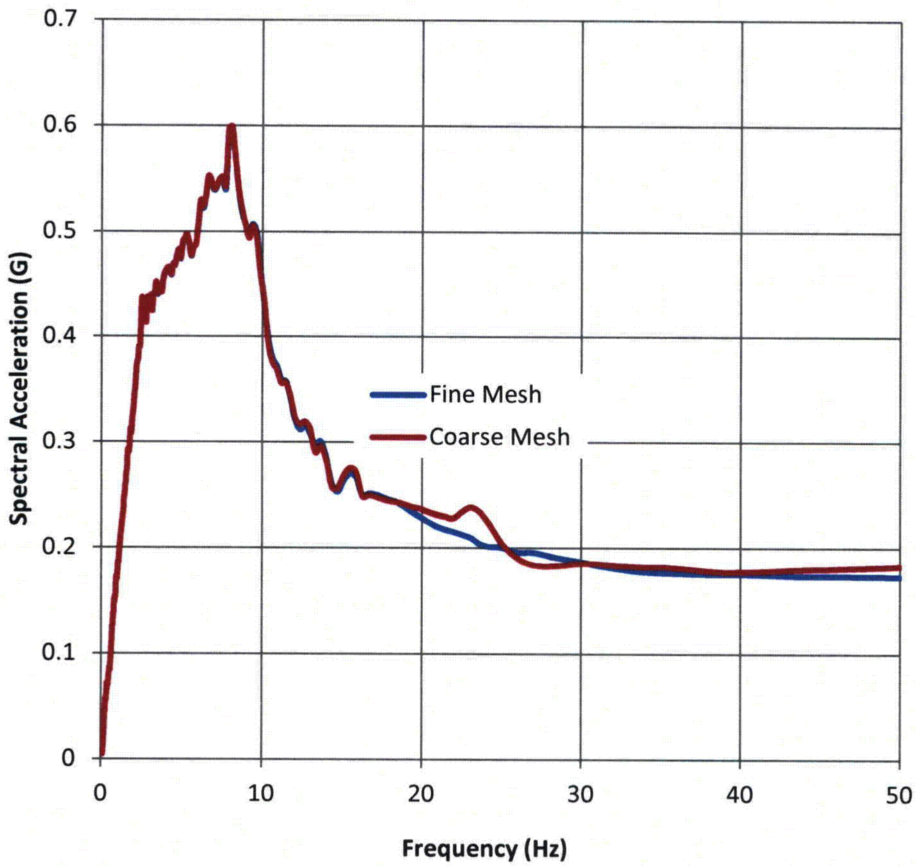


FIGURE 14.
ISRS IN THE Z (VERTICAL) DIRECTION ON TOP OF THE NORTH SIDE FOREBAY WALL (WALL ADFG IN FIGURE 5)

Response Question Part 2:

In the SSI analysis of the Common Basemat Intake Structures (CBIS), the response to seismic wave excitation is governed by the lower bound soil criteria, which has a much lower stiffness than the concrete structural elements. For the SSI analysis of the CBIS, the allowable soil layer thickness (soil mesh in the vertical direction) is determined by using the simple rule that the layer thickness must not exceed one-fifth of the wave length of the highest frequency of analysis:

$$H <= \frac{V_s}{5f_{CF}}$$

Where, H = Soil layer thickness (soil mesh in the vertical direction)

V_s = Shear wave velocity in the soil layer, and

f_{CF} = Cut off frequency (maximum frequency that can pass through the corresponding soil layer)

The lower bound (LB) soil in the CBIS area has the minimum shear velocity. As a result, the refinement of the soil mesh in the vertical direction is governed by the vertical wave propagation requirement for the lower bound soil.

The soil layer thickness (soil mesh in the vertical direction) for the CBIS SSI analysis is determined by using the lower bound soil shear wave velocities (Table 3F-7, FSAR Appendix 3F-7) for all depths in the SSI model. Table 3F-7 (FSAR, Appendix 3F-7) provides the lower bound soil strain compatible properties for 50 soil layers. The 50 soil layers in Table 3F-7 (FSAR, Appendix 3F-7) are further refined in order to achieve the 50 Hz cutoff frequency in the SSI analysis. The refined soil layer thicknesses used in the SSI analysis of the CBIS (using RIZZO's SASSI program version 1.3a) is shown in Column 2 of Table 1, which lists the values for 100 soil layers up to a maximum depth of 361.4 ft. Column 7 of Table 1 shows the cutoff frequency for the soil layer computed using the corresponding soil thickness (Column 2) and the lower bound soil shear wave velocity (Column 5). The lower bound strain compatible soil properties used in the SSI analysis (Table 1) may be slightly different from those provided in Table 3F-7 (FSAR, Appendix 3F-7) due to layer refinement and weighted average soil property computation. Weighted average soil strain compatible properties are required in the SSI analysis. SASSI requires the CBIS structural element mesh to align with the adjacent soil layer thicknesses over the depth of embedment. Similarly, the SSI model for the best estimate and upper bound soil cases consist of similar soil layer thicknesses as presented in Table 1, but with the strain compatible soil properties described in Table 3F-6 (FSAR, Appendix 3F-6) and Table 3F-8 (FSAR, Appendix 3F-8), respectively.

TABLE 1. REFINED SOIL LAYERS AND STRAIN COMPATIBLE PROPERTIES FOR LOWER BOUND SOIL USED IN SSI ANALYSIS OF CBIS

Layer No.	Thickness (ft)	Bottom Depth (ft)	Bottom Ele. (ft)	V_s (ft/s)	V_p (ft/s)	Max. Passing Freq. (Hz)
1	2.1	2.10	7.90	535.8	1115.4	51
2	1.8	3.90	6.10	519.5	1081.3	58
3	1.8	5.70	4.30	462.2	962.1	51
4	1.7	7.40	2.60	439.4	1569.2	52
5	1.7	9.10	0.90	418.3	2132.9	49
6	1.6	10.70	-0.70	408.2	2081.3	51
7	1.6	12.30	-2.30	395.2	2014.9	49
8	1.6	13.90	-3.90	395.2	2014.9	49
9	1.5	15.40	-5.40	382.6	1951.1	51
10	1.5	16.90	-6.90	374.3	1908.5	50
11	1.5	18.40	-8.40	374.0	1906.9	50
12	1.5	19.90	-9.90	373.1	1902.6	50
13	1.5	21.40	-11.40	380.0	1937.4	51
14	1.5	22.90	-12.90	384.5	1960.6	51
15	1.5	24.40	-14.40	384.5	1960.6	51
16	1.5	25.90	-15.90	410.1	2091.2	55
17	1.5	27.40	-17.40	412.0	2100.5	55
18	1.5	28.90	-18.90	409.8	2089.6	55
19	1.5	30.40	-20.40	403.9	2059.7	54
20	1.5	31.90	-21.90	403.9	2059.7	54
21	1.5	33.40	-23.40	404.6	2062.9	54
22	1.6	35.00	-25.00	405.0	2065.1	51
23	1.6	36.60	-26.60	405.0	2065.1	51
24	1.6	38.20	-28.20	627.3	3198.7	78
25	2.8	41.00	-31.00	913.2	4656.3	65
26	3.6	44.60	-34.60	911.5	4648.0	51
27	3.6	48.20	-38.20	909.9	4639.8	51
28	3.6	51.80	-41.80	908.4	4632.1	50
29	3.6	55.40	-45.40	899.9	4588.4	50
30	3.6	59.00	-49.00	894.8	4562.8	50
31	3.6	62.60	-52.60	892.4	4550.6	50
32	3.6	66.20	-56.20	890.7	4541.7	49
33	3.6	69.80	-59.80	889.4	4535.2	49
34	3.6	73.40	-63.40	888.4	4529.7	49
35	3.6	77.00	-67.00	886.8	4522.1	49
36	3.6	80.60	-70.60	885.6	4515.9	49
37	3.6	84.20	-74.20	885.6	4515.9	49
38	3.5	87.70	-77.70	883.5	4504.9	50
39	3.5	91.20	-81.20	882.9	4501.7	50
40	3.5	94.70	-84.70	882.9	4501.7	50
41	3.5	98.20	-88.20	880.6	4490.2	50
42	3.5	101.70	-91.70	880.4	4489.1	50
43	3.0	104.70	-94.70	880.4	4489.1	59
44	3.5	108.20	-98.20	875.4	4463.6	50
45	3.5	111.70	-101.70	875.4	4463.6	50
46	3.0	114.70	-104.70	875.4	4463.6	58

TABLE 1. REFINED SOIL LAYERS AND STRAIN COMPATIBLE PROPERTIES FOR LOWER BOUND SOIL USED IN SSI ANALYSIS OF CBIS (CONTINUED)

Layer No.	Thickness (ft)	Bottom Depth (ft)	Bottom Ele. (ft)	V_s (ft/s)	V_p (ft/s)	Max. Passing Freq. (Hz)
47	3.4	118.10	-108.10	842.2	4294.4	50
48	3.4	121.50	-111.50	842.2	4294.4	50
49	3.2	124.70	-114.70	842.2	4294.4	53
50	3.3	128.00	-118.00	833.9	4251.9	51
51	3.3	131.30	-121.30	833.9	4251.9	51
52	1.4	132.70	-122.70	833.9	4251.9	119
53	3.4	136.10	-126.10	839.2	4279.2	49
54	3.4	139.50	-129.50	839.2	4279.2	49
55	3.4	142.90	-132.90	852.6	4347.5	50
56	3.4	146.30	-136.30	859.9	4384.8	51
57	3.4	149.70	-139.70	859.9	4384.8	51
58	3.5	153.20	-143.20	865.6	4414.0	49
59	3.5	156.70	-146.70	865.6	4414.0	49
60	3.0	159.70	-149.70	865.6	4414.0	58
61	3.5	163.20	-153.20	864.0	4405.7	49
62	3.5	166.70	-156.70	864.0	4405.7	49
63	3.0	169.70	-159.70	864.0	4405.7	58
64	3.4	173.10	-163.10	862.4	4397.5	51
65	3.4	176.50	-166.50	862.4	4397.5	51
66	3.2	179.70	-169.70	862.4	4397.5	54
67	3.4	183.10	-173.10	860.8	4389.2	51
68	3.4	186.50	-176.50	860.8	4389.2	51
69	3.2	189.70	-179.70	860.8	4389.2	54
70	3.5	193.20	-183.20	865.7	4414.3	49
71	3.5	196.70	-186.70	865.7	4414.3	49
72	3.0	199.70	-189.70	865.7	4414.3	58
73	3.5	203.20	-193.20	925.4	4718.9	53
74	3.5	206.70	-196.70	925.4	4718.9	53
75	3.0	209.70	-199.70	925.4	4718.9	62
76	4.4	214.10	-204.10	1093.3	4800.0	50
77	4.4	218.50	-208.50	1093.3	4800.0	50
78	4.4	222.90	-212.90	1308.0	4800.0	59
79	5.6	228.50	-218.50	1388.5	4800.0	50
80	4.6	233.10	-223.10	1588.6	4800.0	69
81	6.6	239.70	-229.70	1659.2	4800.0	50
82	6.8	246.50	-236.50	1700.9	4853.7	50
83	6.5	253.00	-243.00	1667.1	4826.5	51
84	6.5	259.50	-249.50	1634.2	4800.0	50
85	6.5	266.00	-256.00	1626.7	4800.0	50
86	6.4	272.40	-262.40	1617.7	4800.0	51
87	6.4	278.80	-268.80	1605.6	4800.0	50
88	6.4	285.20	-275.20	1551.6	4800.0	48
89	6.4	291.60	-281.60	1541.9	4800.0	48
90	6.2	297.80	-287.80	1533.2	4800.0	49

TABLE 1. REFINED SOIL LAYERS AND STRAIN COMPATIBLE PROPERTIES FOR LOWER BOUND SOIL USED IN SSI ANALYSIS OF CBIS (CONTINUED)

Layer No.	Thickness (ft)	Bottom Depth (ft)	Bottom Ele. (ft)	V_s (ft/s)	V_p (ft/s)	Max. Passing Freq. (Hz)
91	6.1	303.90	-293.90	1532.7	4800.0	50
92	6.1	310.00	-300.00	1532.0	4800.0	50
93	6.1	316.10	-306.10	1537.6	4800.0	50
94	6.1	322.20	-312.20	1543.1	4800.0	51
95	6.1	328.30	-318.30	1568.4	4800.0	51
96	6.2	334.50	-324.50	1668.3	4800.0	54
97	6.3	340.80	-330.80	1715.0	4800.0	54
98	6.6	347.40	-337.40	1726.1	4800.0	52
99	7.0	354.40	-344.40	1725.7	4800.0	49
100	7.0	361.40	-351.40	1725.4	4800.0	49

Response Question Part 3

There is no discrepancy. The two statements are different and correct within the context of their respective descriptions:

- The 1.5 ft soil mesh size corresponds to the "minimum" soil mesh size as computed for the minimum shear wave velocity of the lower bound soil. The minimum shear wave velocity for the intake structure site is 373.1 ft/s from the lower bound soil properties (FSAR Table 3F-7, layer 6). Therefore, the minimum mesh size for the 50 Hz cut off frequency provided for in the SASSI model is:

$$H_{max} = \frac{V_s}{5f_{CF}} = \frac{373.1 \text{ fps}}{5 * 50 \text{ Hz}} = 1.5 \text{ ft}$$

- The 1.6 ft soil mesh is the "average" soil mesh size in the embedment depth of the CBIS. The first 22 soil layers over the embedment depth of the CBIS are shown in Table 2 and the average soil mesh size for this region is 1.6 ft.

TABLE 2.
SOIL MESH SIZE IN THE VERTICAL DIRECTION OVER THE EMBEDMENT DEPTH OF THE CBIS

Layer No.	Thickness (ft)	Bottom Depth (ft)
1	2.1	2.10
2	1.8	3.90
3	1.8	5.70
4	1.7	7.40
5	1.7	9.10
6	1.6	10.70
7	1.6	12.30
8	1.6	13.90
9	1.5	15.40
10	1.5	16.90
11	1.5	18.40
12	1.5	19.90
13	1.5	21.40
14	1.5	22.90
15	1.5	24.40
16	1.5	25.90
17	1.5	27.40

TABLE 2.
SOIL MESH SIZE IN THE VERTICAL DIRECTION OVER THE EMBEDMENT DEPTH OF THE CBIS (CONTINUED)

Layer No.	Thickness (ft)	Bottom Depth (ft)
18	1.5	28.90
19	1.5	30.40
20	1.5	31.90
21	1.5	33.40
22	1.6	35.00
Average	1.6	

Response Question Part 4

In order to investigate the effect of further mesh refinement of the dynamic structural model, a refined version of the western half of the CBIS was created. Figure 15 shows the original western half model of the CBIS used for the SSI analysis. This model consists of 3332 nodes and 3482 plate elements. Figure 16 shows the refined model of the western half the CBIS. Refinement was provided by dividing each of the plate elements in the MWIS and Forebay area into four elements, resulting in 9992 nodes numbers and 10076 plate elements for the refined model. The exterior walls on the western side of the UHS and Forebay area are meshed only in the horizontal direction, since the original mesh in the vertical direction is considered to be fine according to the wave propagation requirement for the soil.

In order to evaluate the effect of further mesh refinement of the SASSI model, a sensitivity analysis was performed for the models shown in Figure 15 and Figure 16, considering a fixed base condition. The plate material and geometric properties of the models are similar to the model originally used for the SSI analysis of the CBIS. For this sensitivity analysis, the ground motions of the Best Estimate (BE) soil are used in the X (N-S), Y (E-W) and Z (Vertical) directions. A structural damping of 5 percent is considered. A symmetric boundary condition is introduced at the middle plane when the ground motion in the X (N-S) and Z (Vertical) directions are considered. An anti-symmetric boundary condition is considered when the ground motion is applied in the Y (E-W) direction.

Using the SSI results, average ISRS are computed at the ground floor (El. 0.0 ft) and second floor (El. 11.5 ft) inside the UHS-MWIS. The average ISRS is computed for each floor in three directions using control points. Eight control points are used in the ground floor and four control points are used in the second floor. The control points for the coarse and fine mesh models are shown on Figure 17 and Figure 18, respectively. The resulting ISRS are shown on Figure 19 through Figure 21 demonstrating acceptable agreement in the N-S and vertical direction; thus, no further refinement is required. The E-W direction shows differences of up to 7 percent in the peak response, attributed to the refinement of the interior walls along the E-W direction of the UHS MWIS. These walls do not influence the response of the structure in the N-S and vertical directions. Figure 22 shows the ISRS obtained with the model after the refinement of some of the interior walls.

These results indicate that a refined model may reduce the relatively small difference in the E-W direction by improving the accuracy of the results. However, the differences are small and the current mesh sizing is acceptable.

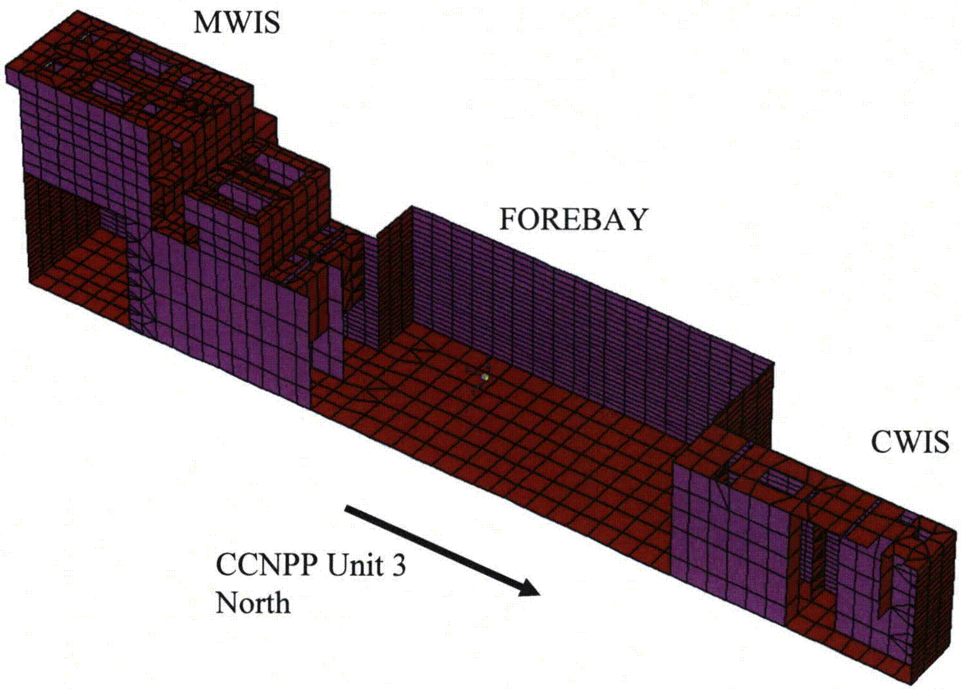


FIGURE 15. CURRENT SASSI STRUCTURAL MODEL (RELATIVE COARSE MESH) HALF WEST SIDE OF THE CBIS

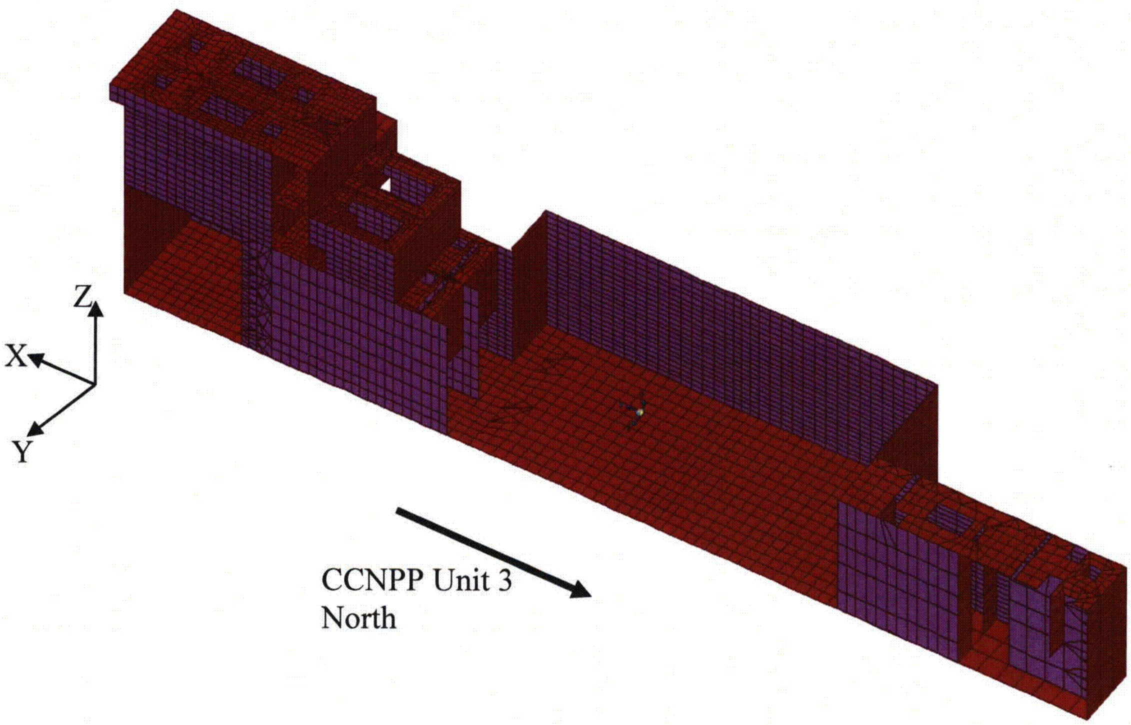


FIGURE 16. REFINED SASSI MODEL

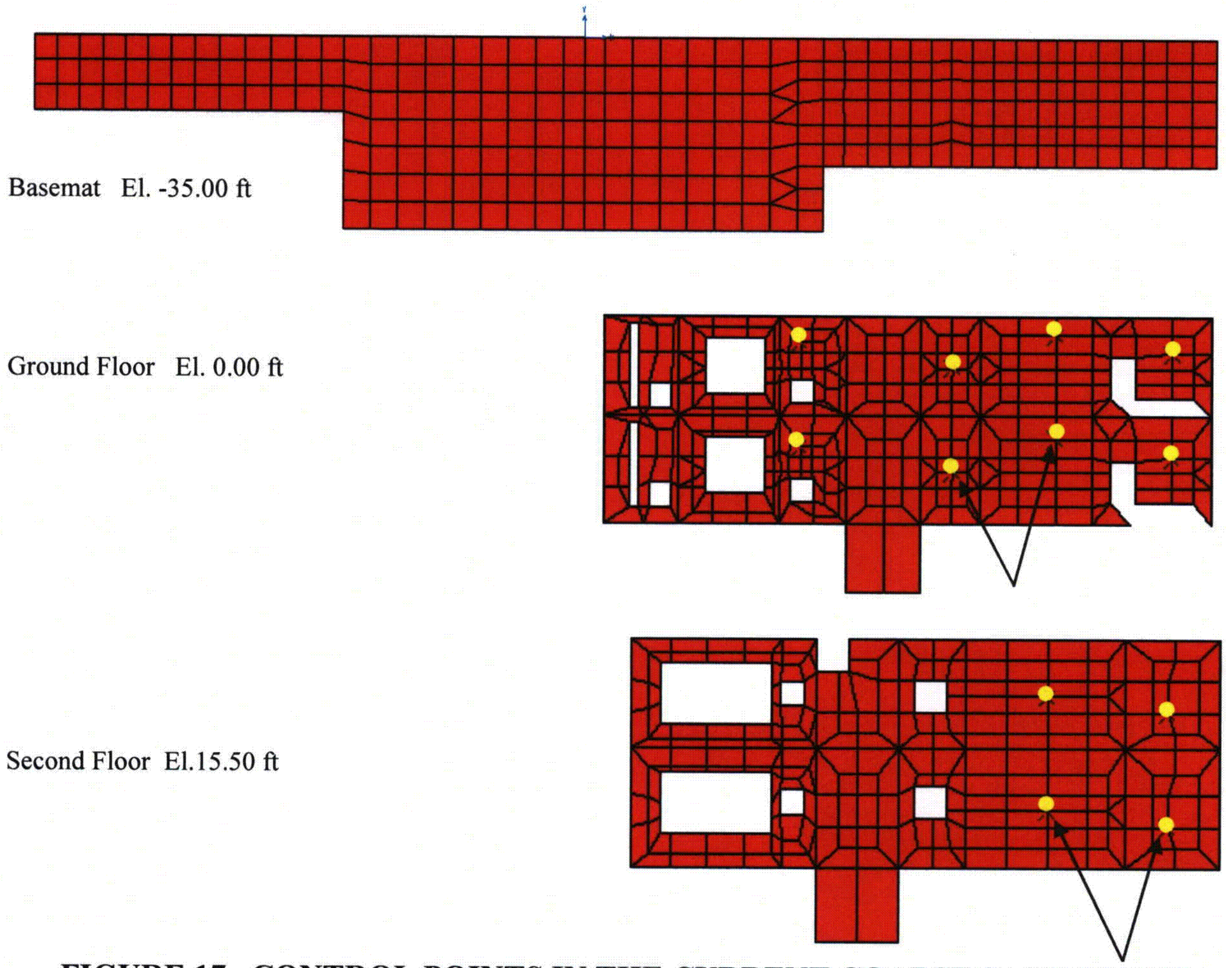


FIGURE 17. CONTROL POINTS IN THE CURRENT COARSE SASSI MODEL

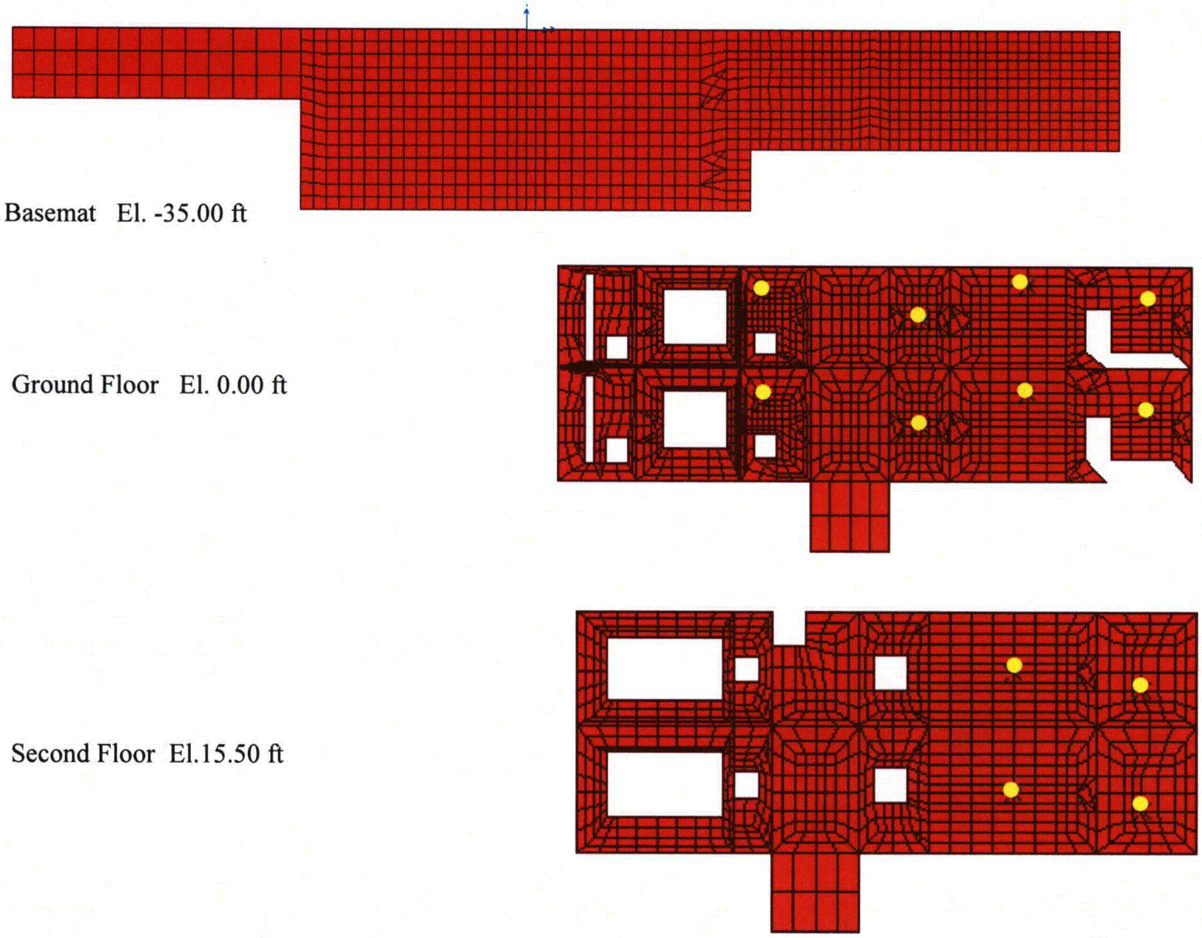
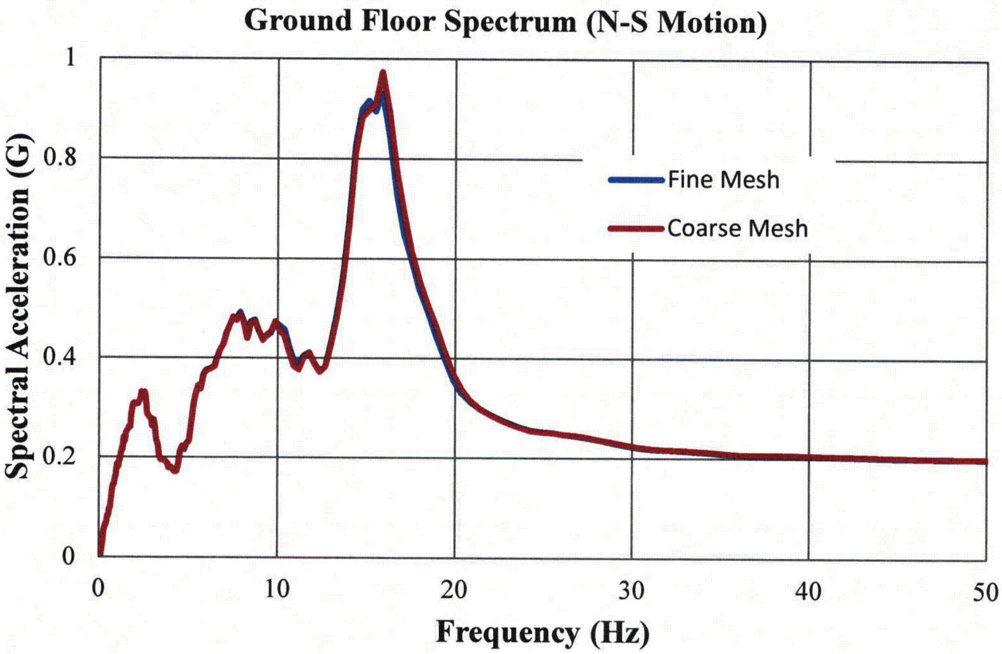


FIGURE 18. CORRESPONDING CONTROL POINTS IN THE SASSI REFINED MODEL



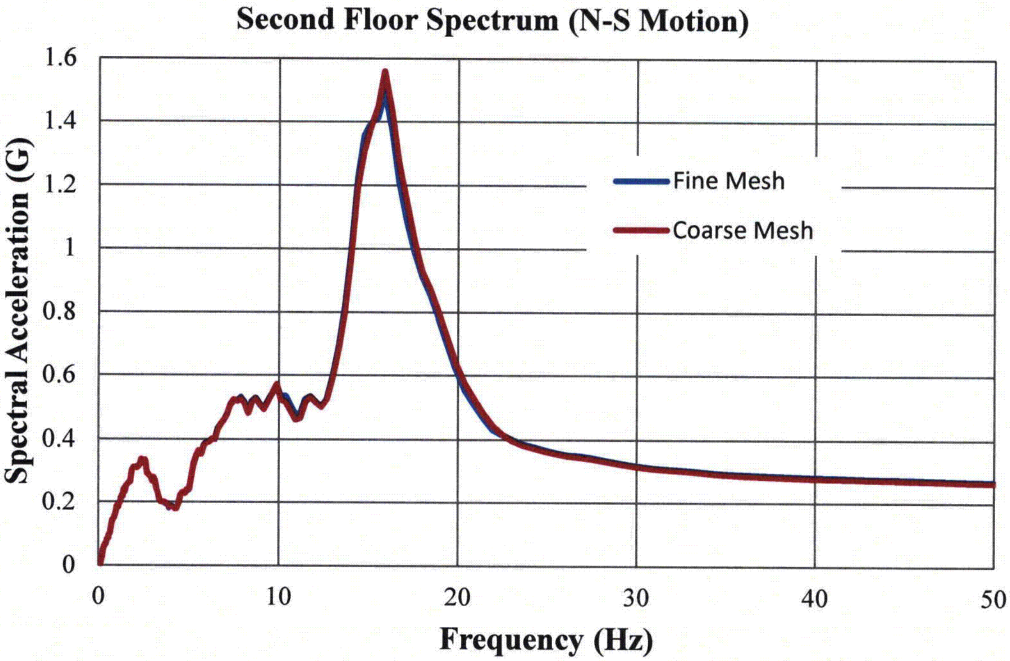
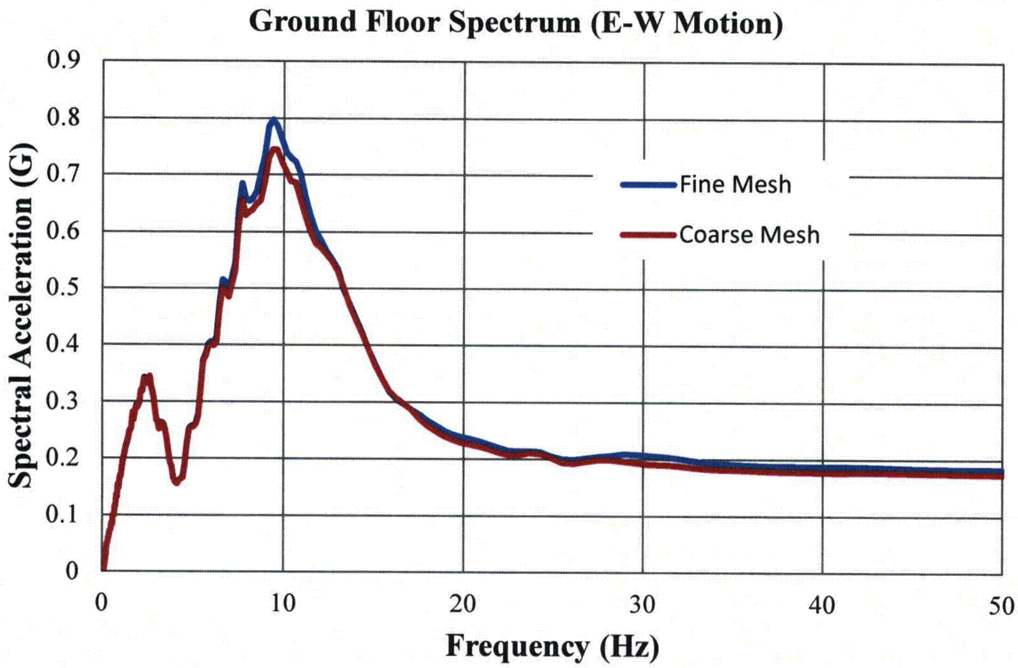


FIGURE 19. ISRS N-S GROUND MOTION



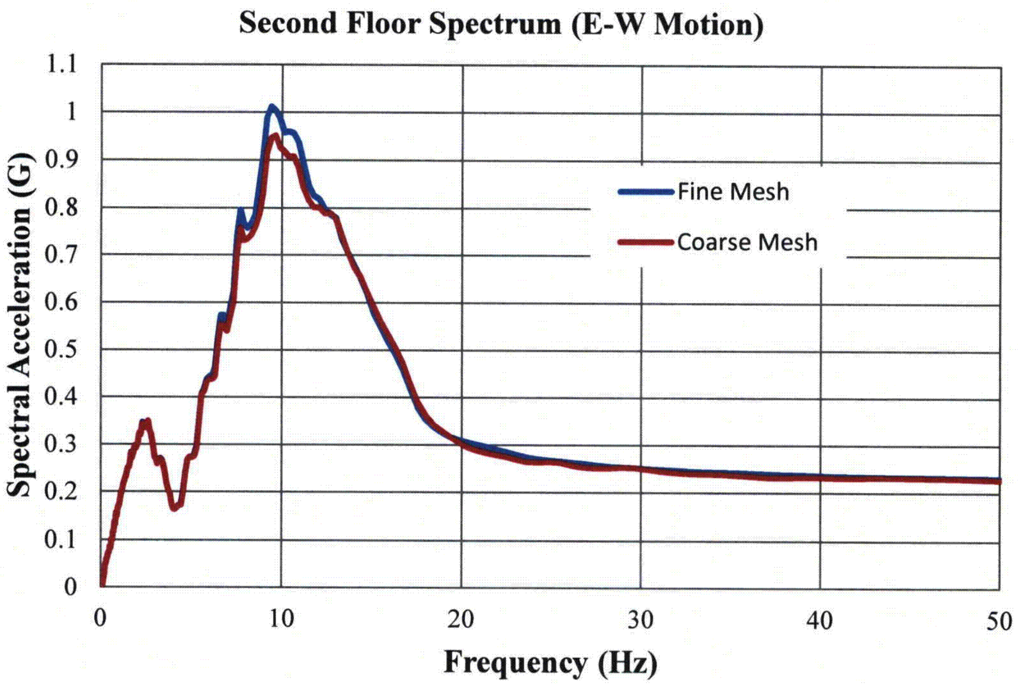


FIGURE 20. ISRS E-W GROUND MOTION

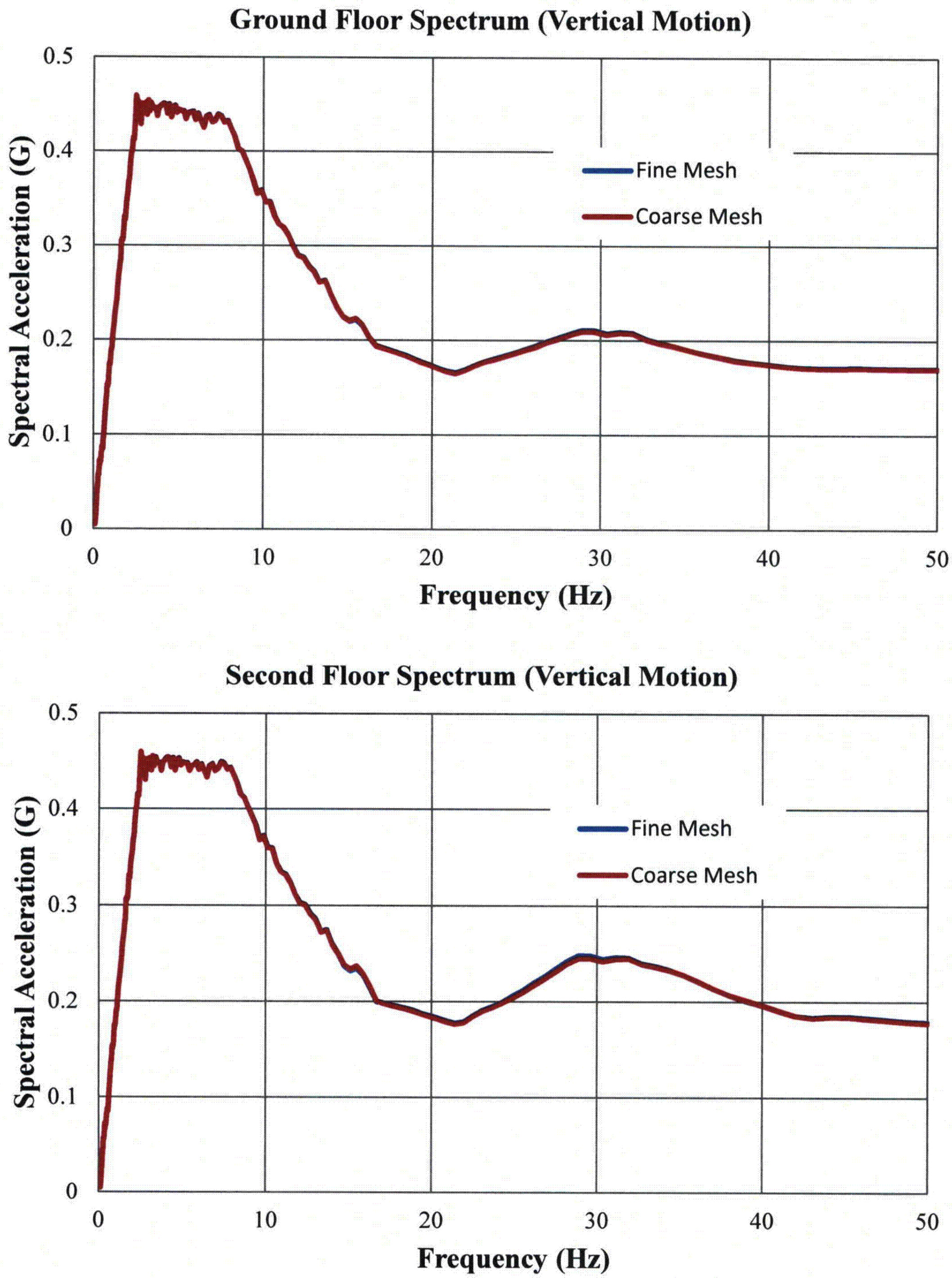
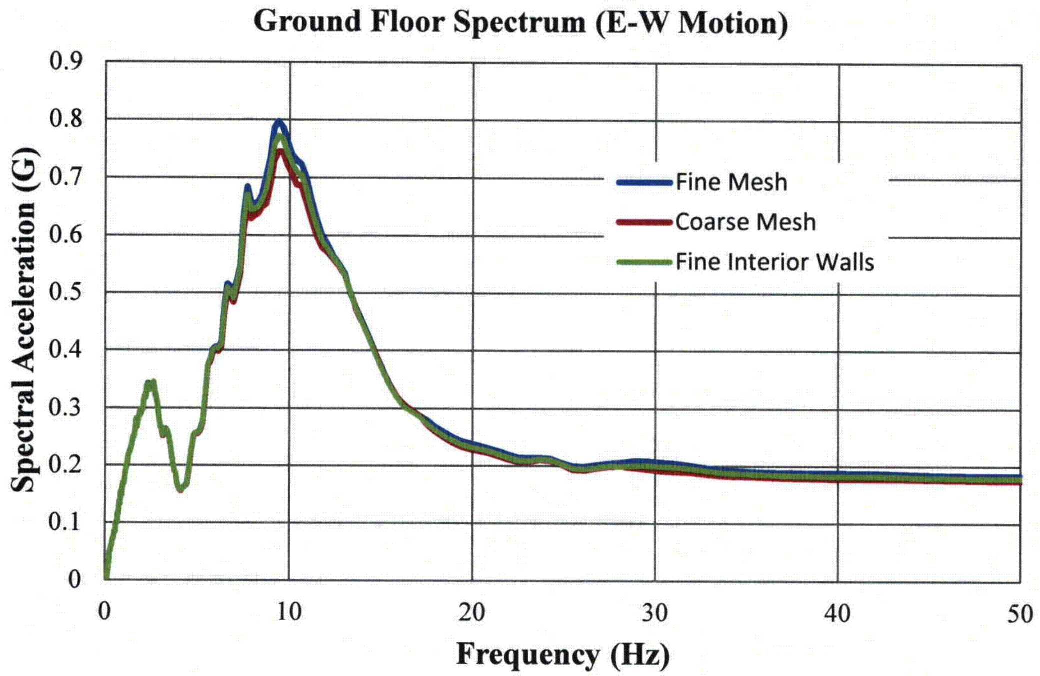


FIGURE 21. ISRS VERTICAL GROUND MOTION



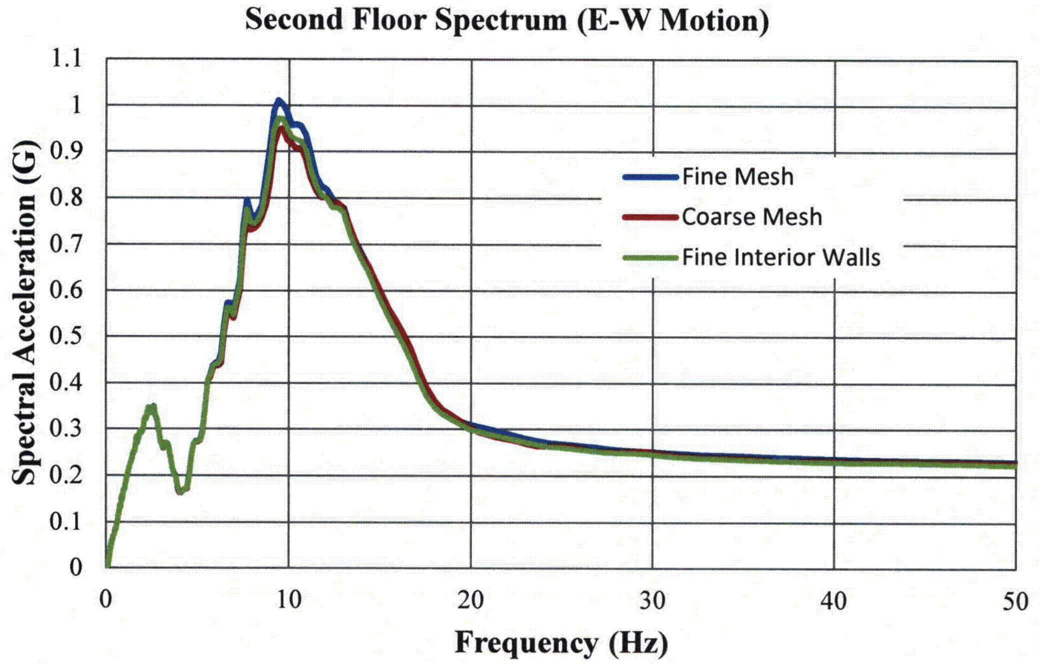


FIGURE 22. CORRECTED ISRS E-W GROUND MOTION

COLA Impact

The COLA FSAR will not be revised as a result of this response.