From: Tai, Tom
Sent: Tuesday, April 19, 2011 4:40 PM
To: STPCOL
Cc: Wunder, George; Tonacci, Mark
Subject: FW: Draft Responses
Attachments: Response to Issues 3, 7, and 9 (041911).pdf

fyi

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From: Price, John E [mailto:jeprice@STPEGS.COM]
Sent: Tuesday, April 19, 2011 4:20 PM
To: Tai, Tom
Cc: Hawkins, Kimberly; Chakravorty, Manas; Chakrabarti, Samir; Chappell, Coley
Subject: Draft Responses

Tom,

Please find attached a file providing draft clarifications associated with Issues 3, 7, and 9 as discussed and requested in last week's conference call.

If you have further questions, please contact me at any time. Regards,

John E. Price
Licensing Engineer - STP Units 3 & 4
972.754.8221 (cell)

Hearing Identifier: SouthTexas34Public_EX
Email Number: 2811

Mail Envelope Properties (0A64B42AAA8FD4418CE1EB5240A6FED126A3022D87)

Subject: FW: Draft Responses
Sent Date: 4/19/2011 4:39:45 PM
Received Date: 4/19/2011 4:39:47 PM
From: Tai, Tom

Created By: Tom.Tai@nrc.gov

Recipients:
"Wunder, George" <George.Wunder@nrc.gov>
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"Tonacci, Mark" <Mark.Tonacci@nrc.gov>
Tracking Status: None
"STPCOL" <STP.COL@nrc.gov>
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Files	**Size**	**Date & Time**
MESSAGE	631	4/19/2011 4:39:47 PM
Response to Issues 3, 7, and 9 (041911).pdf		602483

Options
Priority: Standard
Return Notification: No
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Expiration Date:
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Issue 3: Clearly describing in the FSAR how seismic demand for non-seismic II/I structures for stability evaluation is determined

It is not clear from the descriptions in the FSAR as to how the seismic demand is determined for the site-specific stability evaluation of the non-seismic II/I structures considering the influence of nearby heavy structures during SSE. As such, the applicant is requested to describe in sufficient detail in the FSAR the following information:

1. How the FIRS (as outcrop motion) at the foundation level of the non-seismic II/I structures are determined using the site specific SSE input spectra applied at the ground surface
2. How the effects of nearby heavy structures are included in the input response spectra for various soil and backfill conditions
3. Demonstrate that horizontal input response spectra at the foundation level of non-seismic II/I structures is broad band spectra with peak acceleration greater than 0.1g and envelops FIRS
4. Types of seismic analysis performed to determine seismic demand for stability evaluation (i.e., fixed base analysis, equivalent static or dynamic analysis, or SSI analysis) and how the input is specified in the analysis
5. Include 5% damped input response spectra (vertical and horizontal) as amplified by the presence of nearby heavy structures used in the seismic demand evaluation for site-specific stability analysis for non-seismic II/I structures
6. Discuss or refer to appropriate FSAR section of any differences in the method of stability evaluation from that of Category 1 structures

Response:

1&2. For stability evaluation of the Radwaste Building (RWB) and Control Building Annex (CBA), the input motion is determined by enveloping the site-specific SSE response spectra and the induced acceleration response spectra due to site-specific SSE that is determined from an SSI analysis which accounts for the impact of the nearby heavy structure (Reactor Building in case of the RWB and Control Building in case of the CBA). In this SSI analysis, five interaction nodes at the depth corresponding to the bottom elevation of the structure, RWB or CBA, are added to the three dimensional SSI model of the nearby heavy structure. These five interaction nodes correspond to the four corners and the center of the structure. The response spectra at these five nodes are averaged. This analysis is repeated for the upper bound, best estimate, and lower bound in-situ soil properties. Finally, an envelop of these three average spectra and the site-specific SSE spectrum is used as the seismic input to the structure's stability analysis.

3. Attached Figures 1 through 6 show, for the two horizontal and vertical directions, a comparison of the input spectra derived from the analysis described in Items 1&2 above, with the 0.1g Regulatory Guide 1.60 spectra for the RWB and CBA.

It can be seen from these figures that the input spectra for stability analysis envelop the 0.1g Regulatory Guide 1.60 spectra for both structures in all cases.

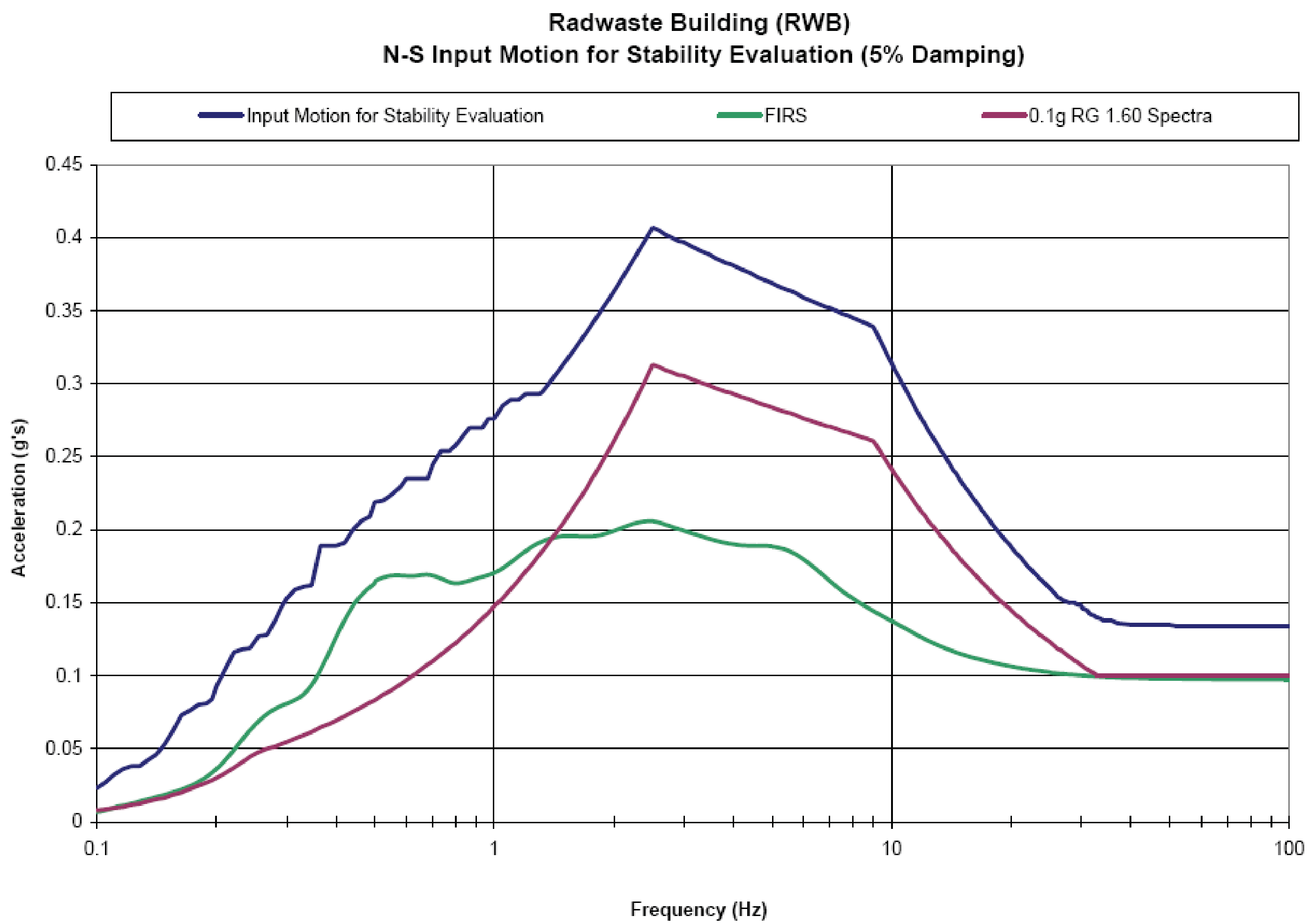
FIRS were not generated for the RWB and CBA, since these are non-Category I structures. The CBA is essentially a surface mounted structure; therefore, the FIRS for this will be essentially the same as the GMRS. As shown in Figures 4 through 6, the input spectrum used for the stability evaluation of the CBA envelops the GMRS, hence FIRS. To demonstrate the same point for the RWB, we have plotted the FIRS (taken from COLA Figures 3H.6-3a, b, and c) for the UHS Basin on Figures 1 through 3. Please note that the foundation of the UHS Basin is about 32 feet below grade whereas the foundation of the RWB is about 45 feet below grade. Therefore, the FIRS for the RWB will be enveloped by the FIRS for the UHS Basin. It can be seen from the comparison shown in Figures 1 through 3 that the input spectra used for the RWB stability analysis envelop the UHS Basin FIRS in all cases, and therefore would envelop the FIRS for the RWB.

4. A fixed base dynamic analysis of the RWB structure was performed, using the input response spectra described in Items 1&2 above, to determine the seismic demand for the stability evaluation. For the CBA, in the stability analysis the seismic inertia forces were determined considering ZPA (zero period accelerations) and peak accelerations from the input response spectra described in Items 1&2 above for the basemat and superstructure, respectively.

5. The input spectra shown in Figures 1 through 6 will be included in COLA.

6. The different formulations for calculation of safety factors against sliding and overturning used in the stability evaluation of Category I and Non-Category I structures are shown in COLA Figures 3H.6-137 and 3H.3-52, respectively, submitted as part of the RAI 03.08.04-30, Supplement 1 response, with NINA letter U7-C-NRC-NINA-110042, dated March 7, 2011. Copies of these figures are shown below as Figures 7 and 8.

Figure 1



Radwaste Building (RWB)
N-S Input Motion for Stability Evaluation (5% Damping)
Input Motion for Stability Evaluation
FIRS
0.1g RG 1.60 Spectra
Acceleration (g's)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.1
1
10
100
Frequency (Hz)

Figure 2

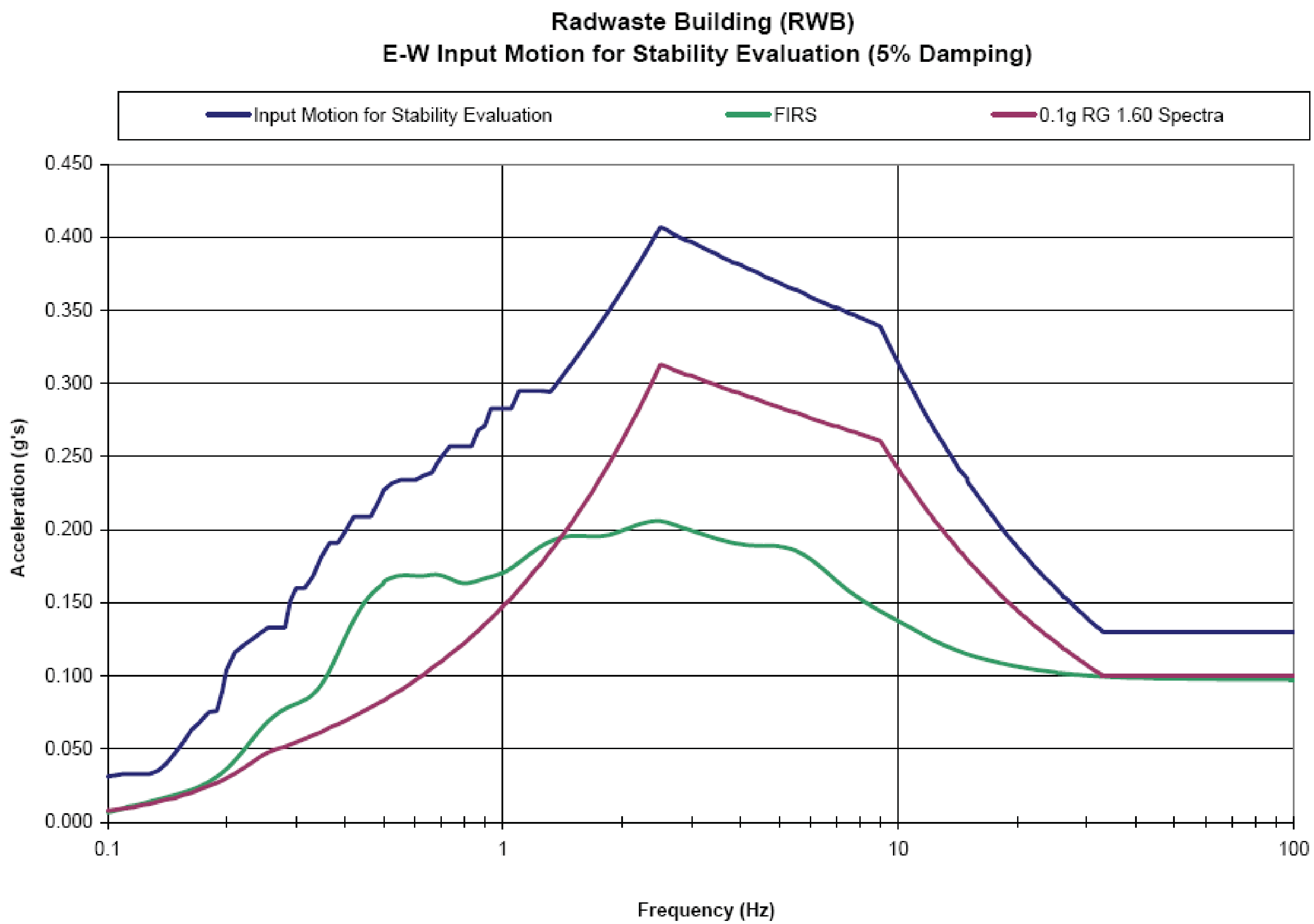

Radwaste Building (RWB)
E-W Input Motion for Stability Evaluation (5% Damping)
Input Motion for Stability Evaluation
FIRS
0.1g RG 1.60 Spectra
Acceleration (g's)
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.1
1
10
100
Frequency (Hz)

Figure 3

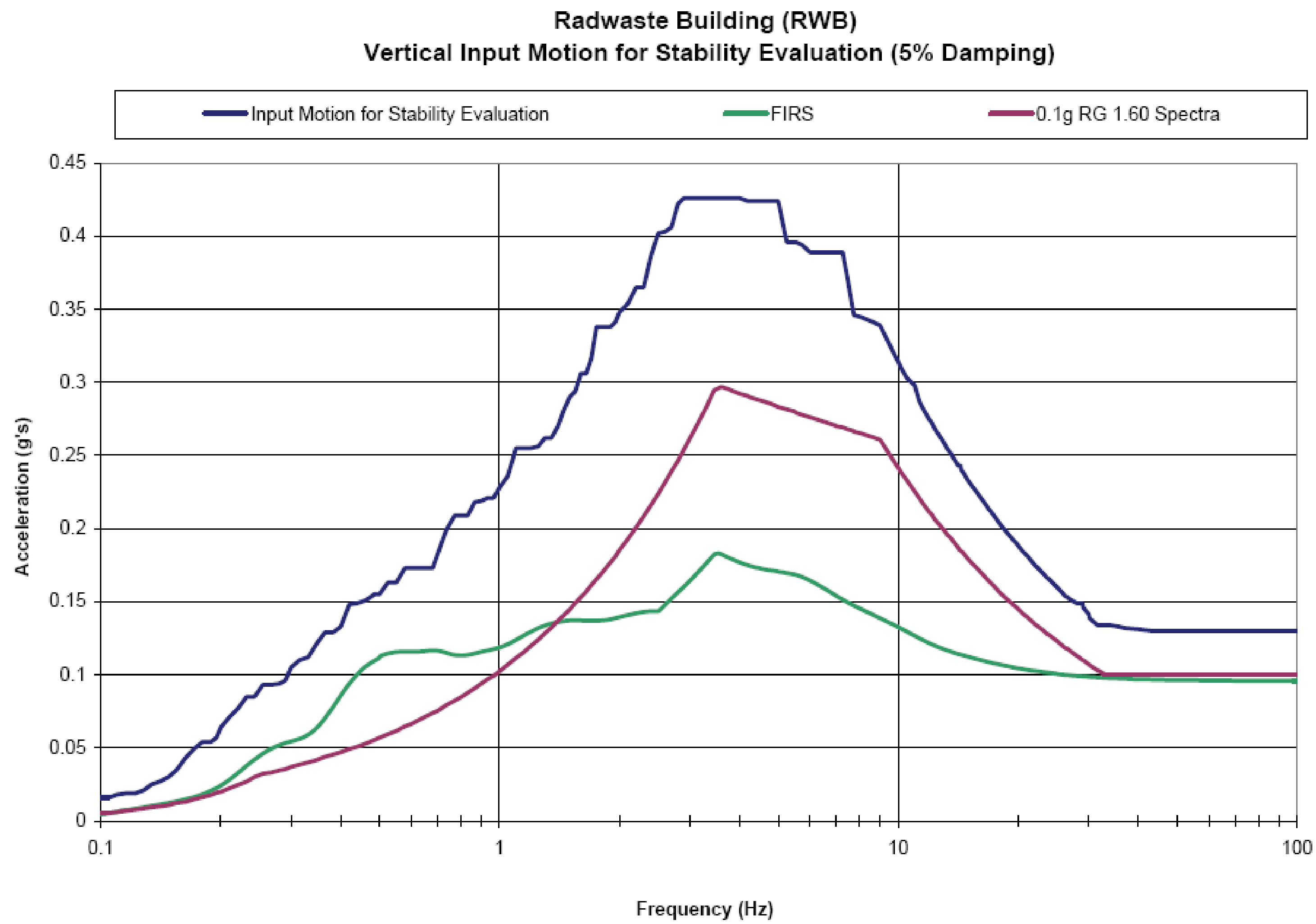

Radwaste Building (RWB)
Vertical Input Motion for Stability Evaluation (5% Damping)
Input Motion for Stability Evaluation
FIRS
0.1g RG 1.60 Spectra
Acceleration (g's)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.1
1
10
100
Frequency (Hz)

Figure 4

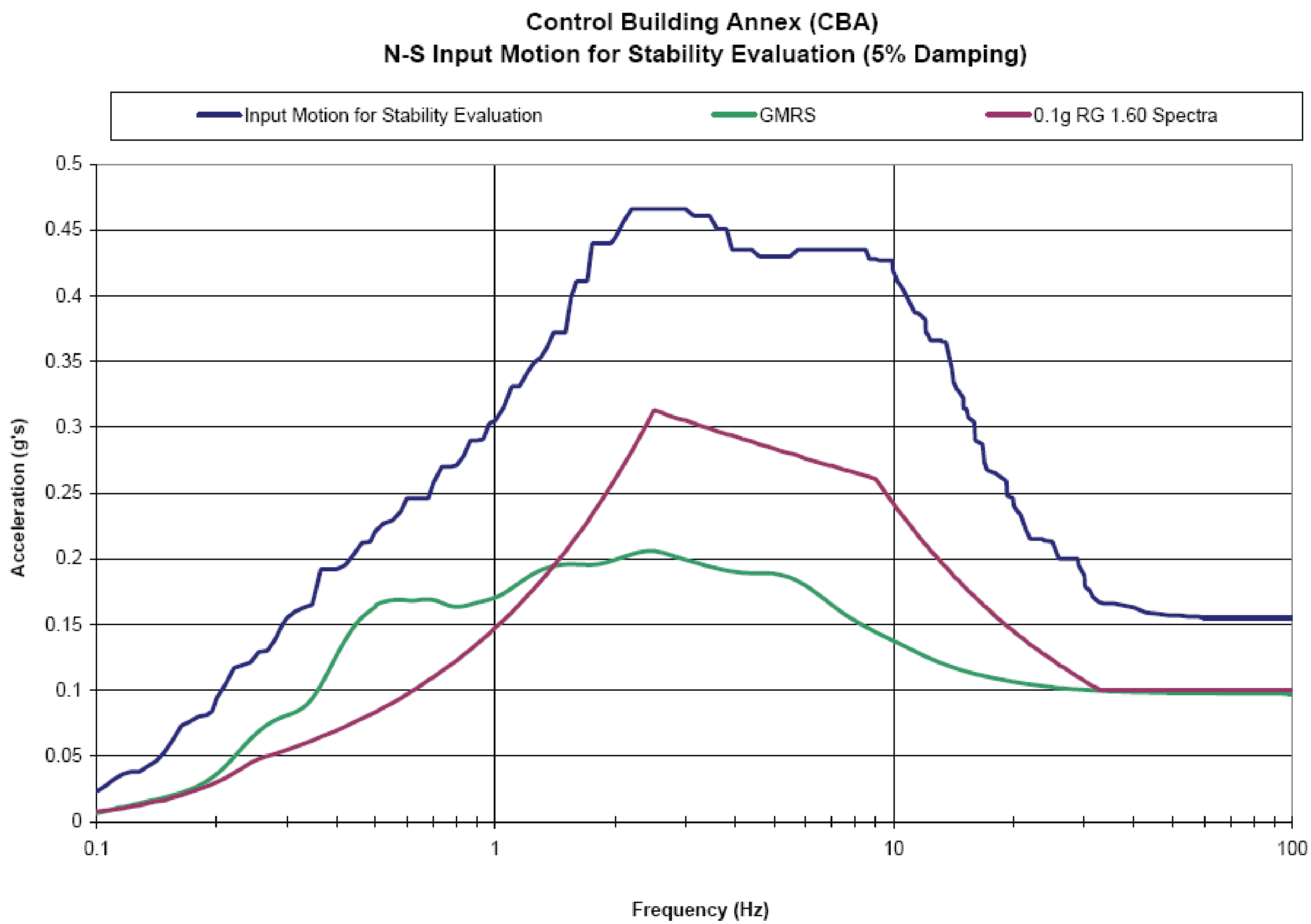
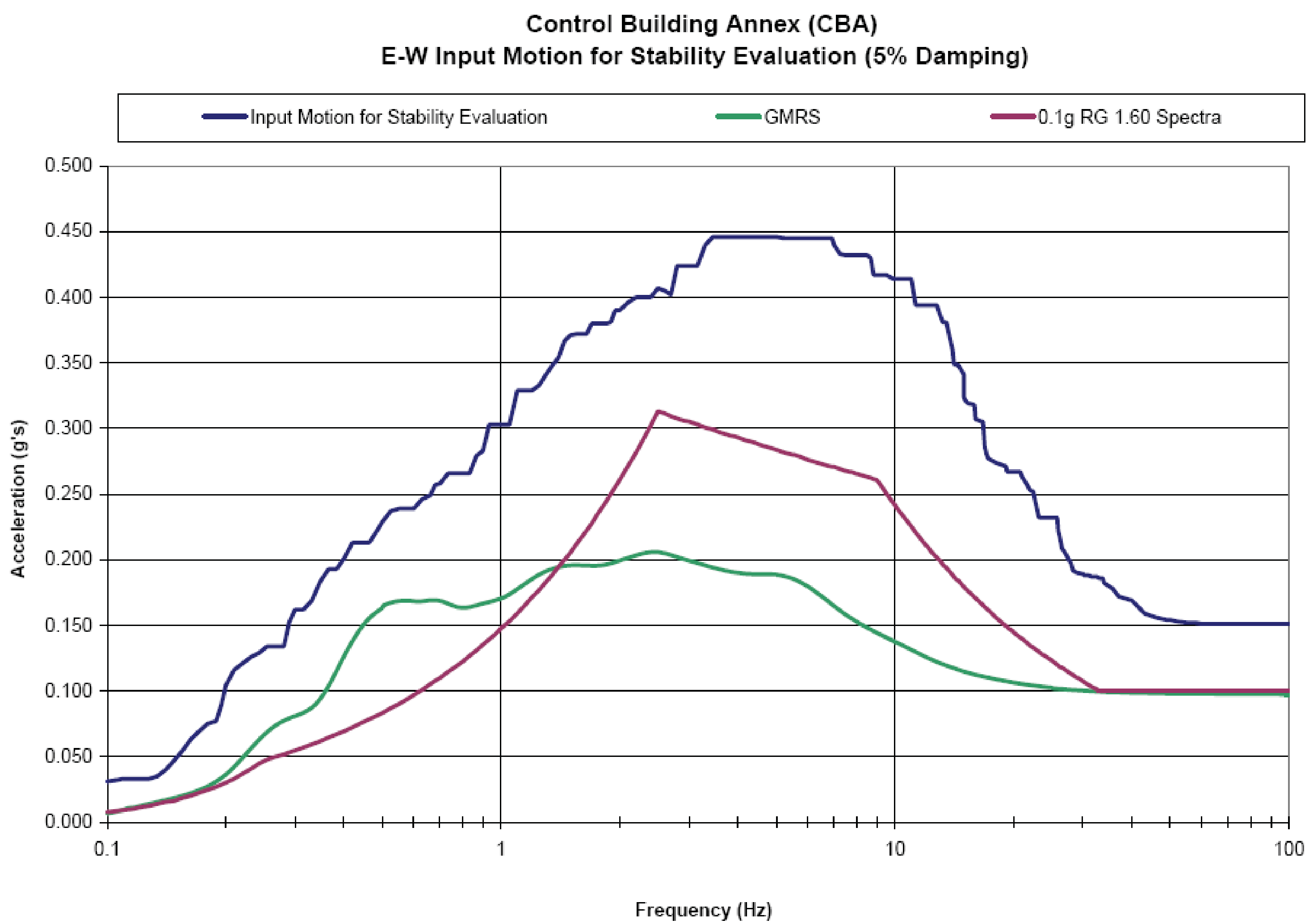
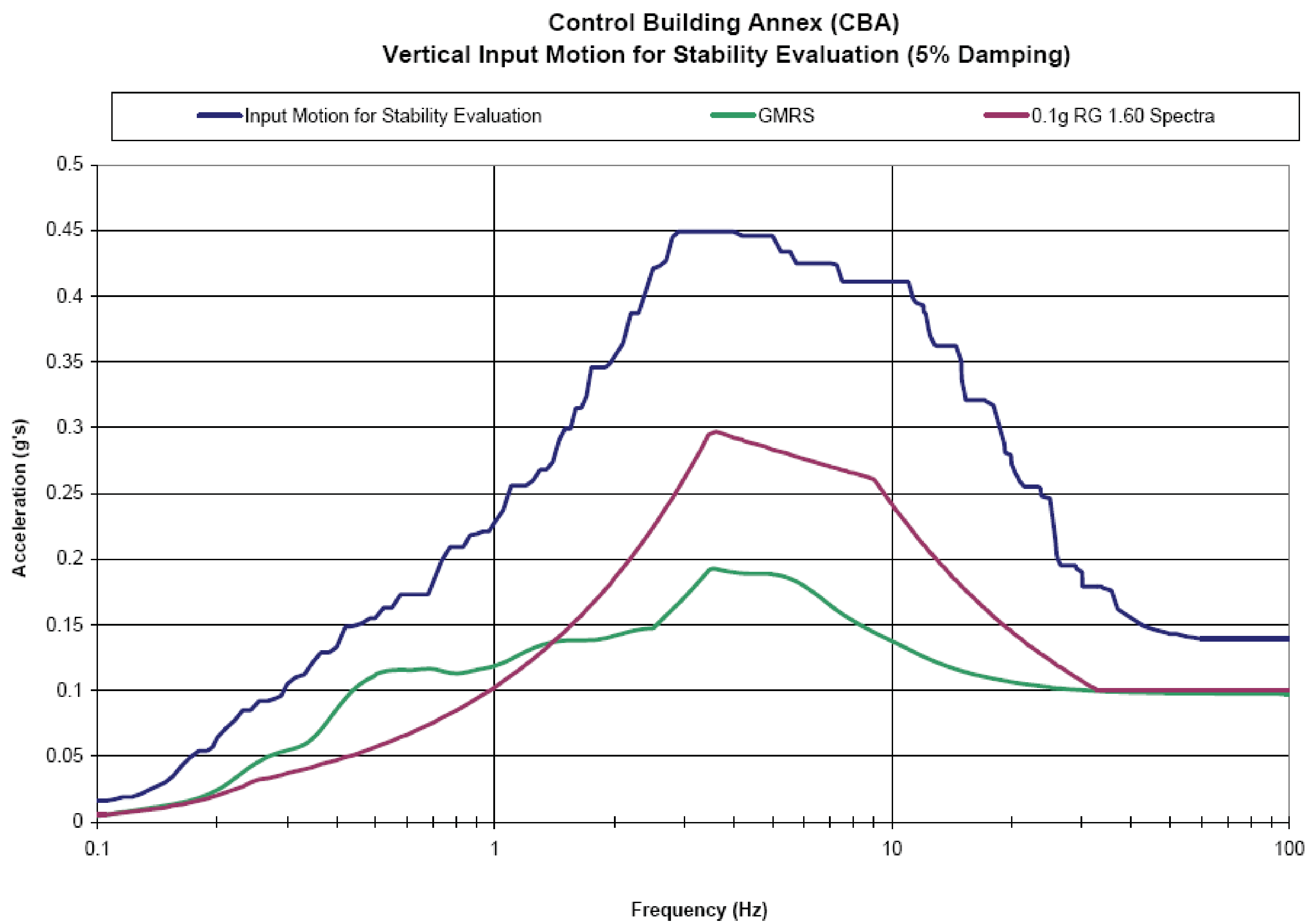

Control Building Annex (CBA)
N-S Input Motion for Stability Evaluation (5% Damping)
Input Motion for Stability Evaluation
GMRS
0.1g RG 1.60 Spectra
Acceleration (g's)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.1
1
10
100
Frequency (Hz)

Figure 5



Control Building Annex (CBA)
E-W Input Motion for Stability Evaluation (5% Damping)
Input Motion for Stability Evaluation
GMRS
0.1g RG 1.60 Spectra
Acceleration (g's)
0.500
0.450
0.400
0.350
0.300
0.250
0.200
0.150
0.100
0.050
0.000
0.1
1
10
100
Frequency (Hz)

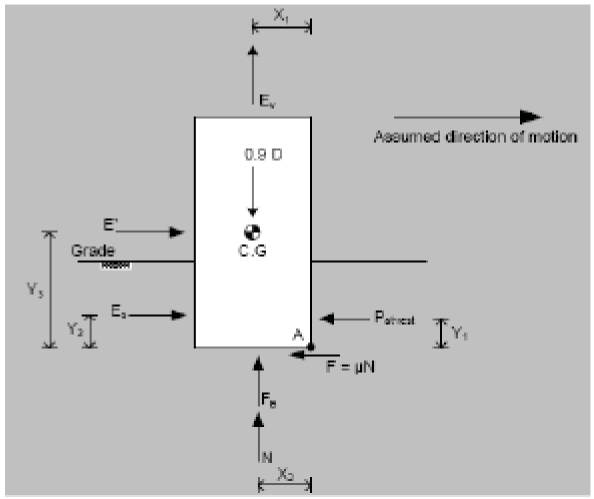
Figure 6



Control Building Annex (CBA)
Vertical Input Motion for Stability Evaluation (5% Damping)
Input Motion for Stability Evaluation
GMRS
0.1g RG 1.60 Spectra
Acceleration (g's)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0.1
1
10
100
Frequency (Hz)

Figure 7

Figure 3H.6-137: Formulations Used for Calculation of Factors of Safety Against Sliding and Overturning



Factors of Safety against Sliding and Overturning about point A are calculated as follows:

$$SF_{sliding} = \frac{P_{at\_rest} + F}{E_s + E'}$$

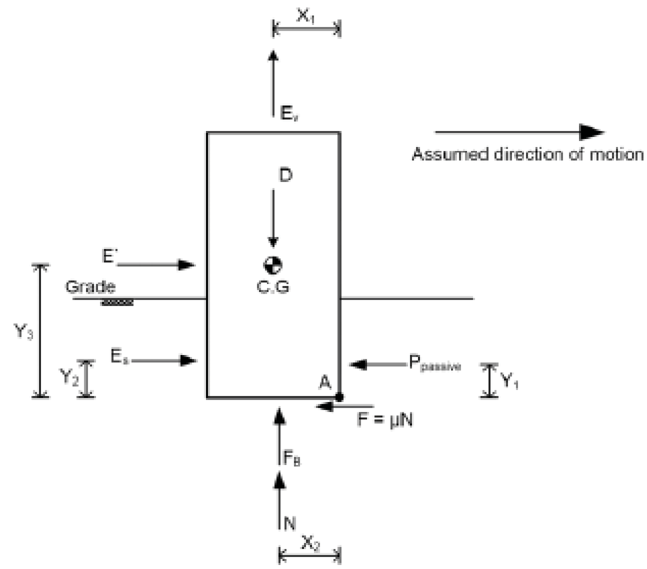
$$SF_{OT\_A} = \frac{(P_{at\_rest})(Y_1) + (0.9D)(X_1)}{(F_B)(X_2) + (E_s)(Y_2) + (E')(Y_3) + (E_v)(X_1)}$$

Where:

$SF_{sliding}$ = Safety factor against sliding
SF_{OT_A} = Safety factor against overturning about "A"
D = Dead load
P_{at_rest} = Total at-rest soil pressure (see Figures 3H.6-48 through 3H.6-50)
$F = \mu N$ = friction force and μ is the coefficient of friction
E_s = Static and dynamic soil pressure (see Figures 3H.6-45 through 3H.6-47)
E' = Self weight excitation in the horizontal direction
E_v = Self weight excitation in the vertical direction
F_B = Buoyancy force
N = Vertical reaction $= 0.9D - F_B - E_v$

Note: If passive pressure is utilized, $P_{passive}$ should be used instead of $P_{at\text{-}rest}$.

Figure 8



Factors of Safety against Sliding and Overturning about point A are calculated as follows:

$$SF_{sliding} = \frac{P_{passive} + F}{E_s + E`}$$

$$SF_{OT\_A} = \frac{(P_{passive})(Y_1) + (D)(X_1) - (F_B)(X_2)}{(E_s)(Y_2) + (E`)(Y_3) + (E_v)(X_1)}$$

Where:

$SF_{sliding}$ = Safety factor against sliding
SF_{OT_A} = Safety factor against overturning about "A"
D = Dead load
$P_{passive}$ = Total passive soil pressure
$F = \mu N$ = friction force and μ is the coefficient of friction
E_s = Static and dynamic soil pressure (active condition)
E` = Self weight excitation in the horizontal direction
E_v = Self weight excitation in the vertical direction
F_B = Buoyancy force
N = Vertical reaction $= D - F_B - E_v$

Figure 3H.3-52: Formulations Used for Calculations of Factors of Stability Against Sliding and Overturning for Seismic II/I Considerations

Issue 7: SAP2000 V&V

The response to RAI.03.07.02-29, Rev. 1, documents additional validation problems for SAP 2000. The validations include:

1) Section cuts
2) Thick shell out-of-plane response
3) Time history modal superposition with shell elements
4) Spectra calculation using thick shell elements

Validation of item “1” was done by hand calculation. For items “2”, “3” and “4”, the benchmark solutions for validation were developed with ANSYS utilizing “SHELL43 “element, which is well suited to model linear, warped, moderately-thick shell structures according to ANSYS User’s Manual. For items “2”, “3” and “4”, the following acceptance criteria were used: 5% for frequencies, 10% for forces, and 15% for spectra. The 5% difference is considered acceptable within the engineering accuracy, while the 10% and 15% criteria may be excessive. The applicant is requested to assess the impact of the above acceptance criteria on the STP 3&4 design.

Response:

The higher difference in forces and spectra is mainly due to differences in the SAP2000 and ANSYS element formulations. As a result of these differences, the generated acceleration time histories from the two programs are somewhat different. Figures 9 through 12 show the comparison of the generated acceleration time histories.

The forces and spectra generated from the SAP2000 program application used for the mesh sensitivity study are not used for design. Therefore, the above acceptance criteria have no impact on STP 3&4 design.

Figure 9

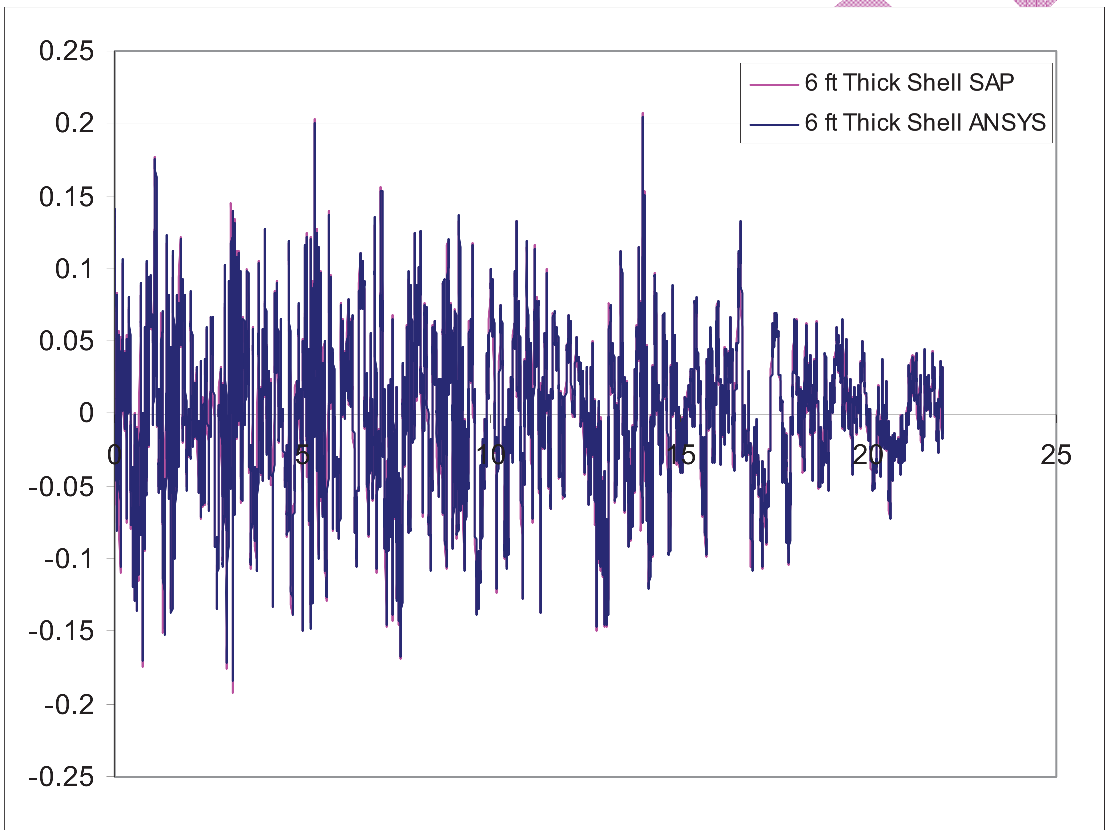
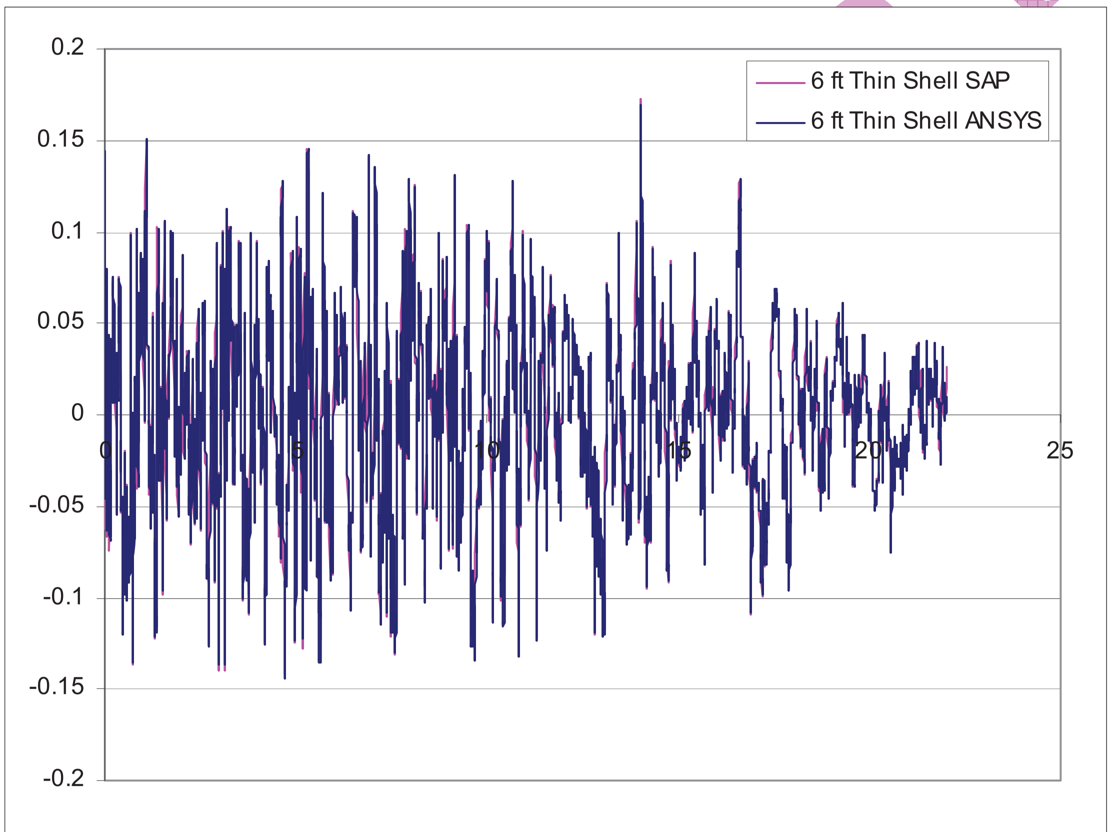
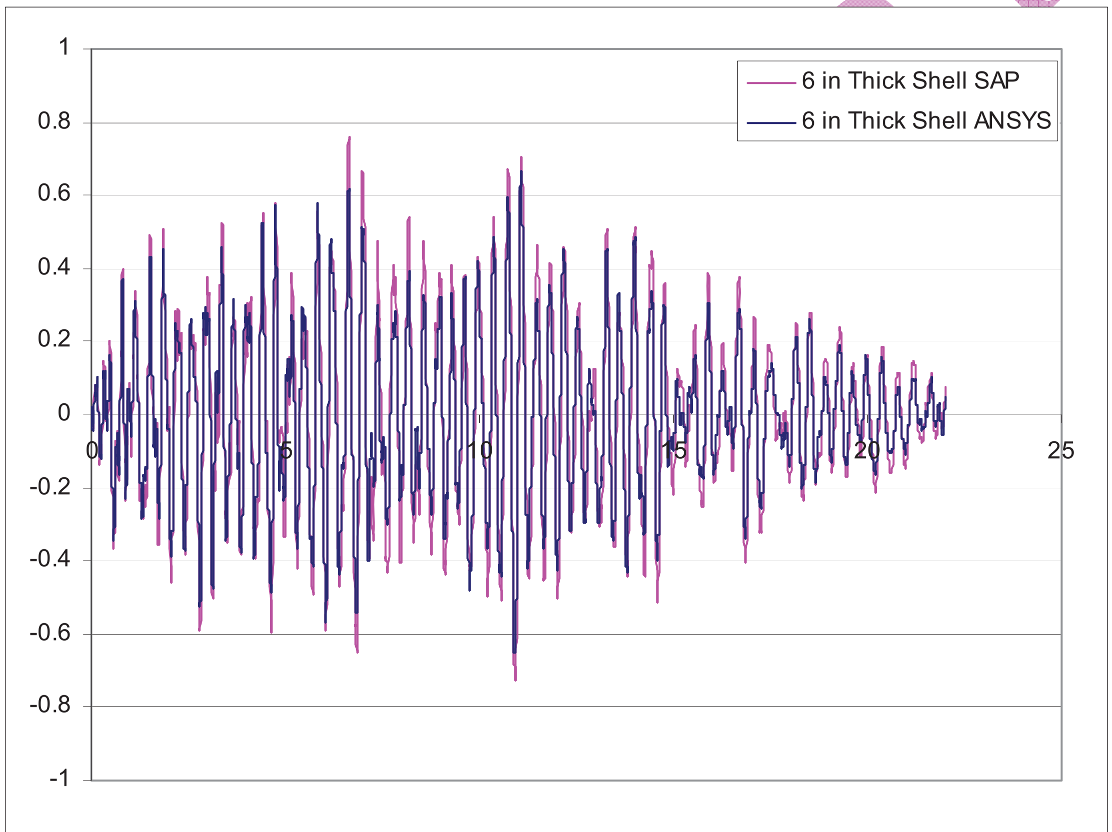

0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
0
5
10
15
20
25
6 ft Thick Shell SAP
6 ft Thick Shell ANSYS

Figure 10



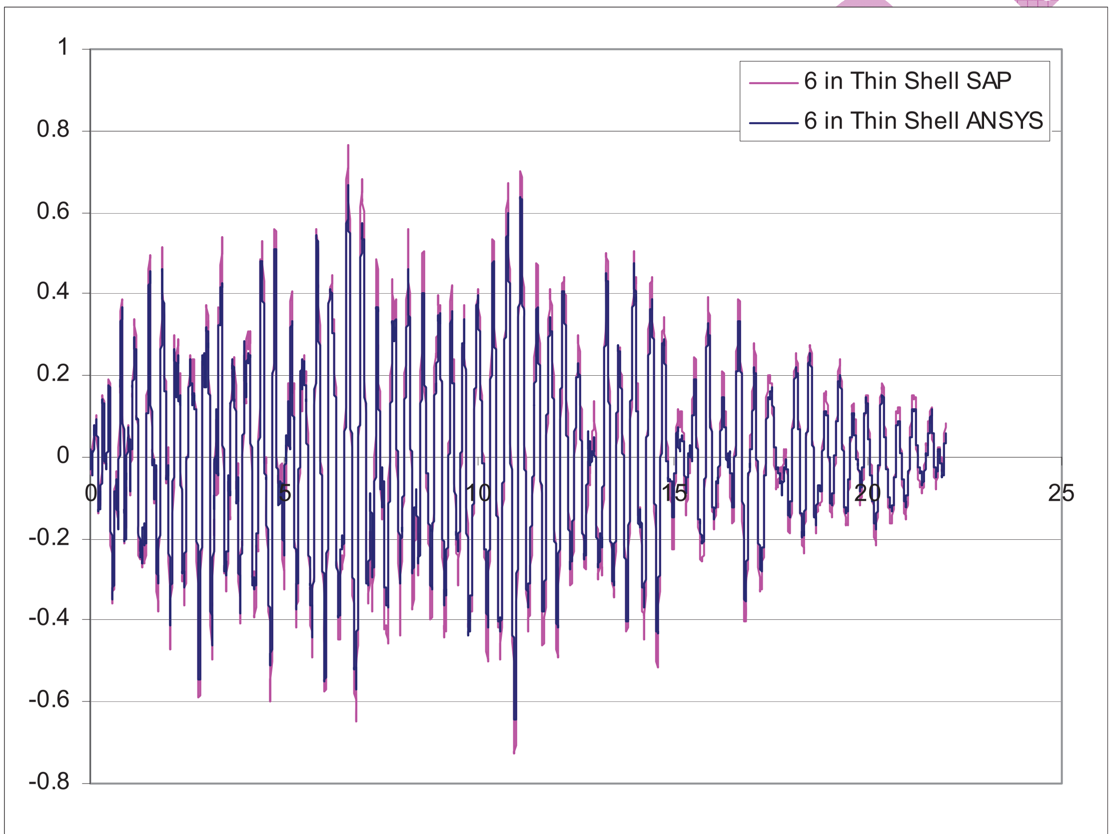
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
0
5
10
15
20
25
6 ft Thin Shell SAP
6 ft Thin Shell ANSYS

Figure 11



1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
5
10
15
20
25
6 in Thick Shell SAP
6 in Thick Shell ANSYS

Figure 12


6 in Thin Shell SAP
6 in Thin Shell ANSYS
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
5
10
15
20
25

Issue 9: DGFOSV Calculation U7-YARD-C-CALC-DESN-6001 Rev. B

In DGFOSV calculation for SSI analysis, U7-YARD-C-CALC-DESN-6001, Rev. B, the refined model spectra values are 14.6% higher at 3.8 Hz than those in the base model. The applicant is requested to provide justification for reconciling this difference.

Response:

The above noted difference has already been addressed in RAI 03.07.01-27, Supplement 1, Revision 1 response submitted with NINA letter U7-C-NRC-NINA-110042, dated March 7, 2011. Please see attached Pages 4 and 5 of Attachment 6 of this NINA letter. The noted difference is discussed on the bottom of Page 4 and found acceptable because the response spectra for lower bound in-situ soil case are bounded by the response spectra for upper bound in-situ soil case.

Analysis Cases, Passing Frequency and Cutoff Frequency for the SSI Analyses:

- The following cases are analyzed for both 4% and 7% structural damping values:

  For full fuel oil tank case:

  - Lower Bound (LB) in-situ soil
  - Mean in-situ Soil
  - Upper Bound (UB) in-situ soil
  - LB backfill over LB in-situ soil
  - Mean backfill over mean in-situ soil
  - UB backfill over UB backfill
  - UB in-situ soil with soil separation
  - UB in-situ soil with cracked concrete

  For Empty fuel oil tank case:

  - UB in-situ soil with empty fuel tank

  Note: For soil separation, cracked concrete and empty fuel oil tank cases, the UB in-situ soil is used because the UB in-situ soil case in general governed.

- A cut-off frequency of 35 Hz was used for all SSI analyses for transfer function calculation.
- Vertical direction passing frequencies (based on one fifth of shear wave length criterion and considering lower bound in-situ soil) are equal to or greater than 33 Hz.
- Horizontal direction passing frequencies are equal to or greater than 33 Hz, except at following locations:

  - For LB in-situ soil, the passing frequency for the top 4 ft soil layer is 30.3 Hz.
  - At the foundation toe, the passing frequencies for in-situ soil are 20 Hz for LB, 25.8 Hz for mean, 31.6 Hz for UB; and for backfill are 23.1 Hz for LB, 28.3 Hz for mean and 34.7 Hz for UB.

To evaluate the effect of 20 Hz passing frequency for LB in-situ case, the foundation toe was divided into two elements, thus increasing the passing frequency to 40 Hz. This refined model with LB in-situ soil properties was analyzed and 5% damped spectra from this model were compared with the spectra from the original model with passing frequency of 20 Hz. The spectra comparison plots are shown in Figures 03.07.01-27.1 through 03.07.01-27.24. The comparison shows that:

- In the X direction, there is insignificant difference between the response spectra from the two models
- In the Y direction, the response spectra from the two models matched well except at frequency of about 3.8 Hz where the refined model produced higher spectra.

However, spectra from both the models are enveloped by the spectra for UB in-situ soil case

- In the vertical direction, the spectra from the two models matched well (insignificant difference)

Based on the above evaluation it is concluded that the horizontal direction passing frequencies are acceptable.

Input Motion:

As described in COLA Part 2, Tier 2 Section 3H.6.7, the input motion considers the impact of the nearby Reactor Building (RB) and UHS/RSW Pump House. From the procedure described in this COLA section it was determined that the 0.3g Regulatory Guide 1.60 spectra envelop all other spectra derived from the SSI analyses to take into account the impact of nearby large structures. Therefore, in this SSI analysis, acceleration time histories consistent with 0.3g Regulatory Guide 1.60 spectra are used as input at the grade elevation.

Response Combination, Enveloping and Spectra Peak Widening:

For all analysis cases, the responses due to two horizontal directions and vertical direction input motions are combined using square-root sum of squares (SRSS) method. Then, the responses from all analysis cases and all locations considered for spectra generation are enveloped to determine one set of un-widened horizontal and vertical response spectra. Finally, per Regulatory Guide 1.122, the enveloped un-widened response spectra are peak widened by plus-minus 15% on the frequency scale to obtain the final response spectra for DGFOSV. The resulting enveloping response spectra for DGFOSV are shown in Figures 3H.6-223 and 3H.6-224 (see Enclosure 1).

2D SSSI Analysis

Two 2D SSSI models are developed and analyzed to evaluate the effects of nearby structures on the three DGFOSV and to calculate the seismic soil pressures on the structures.

The first SSSI model is for a section cut in the North-South direction, consisting of UHS/RSW Pump house, RSW Piping Tunnel, DGFOSV 1B, DGFOSV 1C and RB. The details of this SSSI analysis have been provided in the response to RAI 03.07.02-24, Supplement 1, submitted with STPNOC letter U7-C-STP-NRC-100253 dated November 29, 2010.

The second SSSI model is for a section cut in the East-West direction consisting of diesel generator fuel oil tunnel (DGFOT), DGFOSV 1A and the Crane Foundation Retaining Wall. The model for this SSSI analysis is shown in Figure 3H.6-225 (see Enclosure 1). The model details of the SSSI analysis is provided below.