PMComanchePeakPEm Resource

From: Woodlan, Don [Donald.Woodlan@luminant.com]
Sent: Thursday, April 28, 2011 10:33 AM
To: Galvin, Dennis
Cc: Monarque, Stephen; Valentin, Milton; ComanchePeakCOL Resource; russell_bywater@mnes-us.com; 'tapia_joseph@mnes-us.com'; Conly, John; Evans, Todd
Subject: 2011-04-28 Follow-up on RAI 3.7.3-4, Clarifying Discussion Material
Attachments: image001.gif; 2011-04-27 CPNPP Clarifying Discussion Material re 3-7-3-4 Hydrodynamic pressure vertical ground motion.doc

Dennis,

Attached is some clarifications and discussion related to our response to RAI 162, question 3.7.3-4, for use during today's conference call.

Donald R. Woodlan
Manager, Nuclear Regulatory Affairs
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O- 254-897-6887 C- 214-542-7761

From: Galvin, Dennis [mailto:Dennis.Galvin@nrc.gov]
Sent: Wednesday, April 20, 2011 10:29 AM
To: Woodlan, Don
Cc: Monarque, Stephen; Valentin, Milton; ComanchePeakCOL Resource
Subject: FW: Follow-up on RAI 3.7.3-4

Don,

The staff would like to have a follow-up phone call on this next week.

Thanks,

Dennis Galvin
Project Manager
NRC/NRO/DNRL/NMIP
301-415-6256

From: Galvin, Dennis
Sent: Monday, April 11, 2011 2:51 PM
To: Donald Woodlan
Cc: Monarque, Stephen; ComanchePeakCOL Resource
Subject: FW: Follow-up on RAI 3.7.3-4

Don,

The staff has prepared a summary of the points it raised during the discussion of RAI (Question) 3.7.3-4. Luminant indicated that its path-forward would be to address these points in a revised response to RAI (Question) 3.7.3-4.

Thanks,

Dennis Galvin
Project Manager
NRC/NRO/DNRL/NMIP
301-415-6256

From: Valentin, Milton
Sent: Monday, April 11, 2011 2:38 PM
To: Galvin, Dennis
Subject: Follow-up on RAI 3.7.3-4

Dennis,

Below is the revised list of questions regarding the response to RAI 3.7.3-4.

- Luminant should provide a technical argument justifying why the peak of the base slab ISRS necessarily bounds the peak of the basin wall ISRS
- What are the geometry and configuration of the basin walls being considered, and what is the connection to the geometry and configuration of the base slab being considered? How are the frequencies of the walls and base slab related?
- There are several walls in the UHSRS including external walls and internal walls that separate different rectangular regions. Luminant should identify the walls being considered and describe how the use of the base slab spectrum is conservative for each case.
- It would be very helpful if Luminant were to provide a stronger physical argument for the use of the base slab spectrum.
- It would be very helpful if Luminant were to provide a physical basis for why the use of the base slab spectrum is conservative.
- Where is the base slab ISRS derived?
- What does the 10 Hz peak in the base slab ISRS represent? That is, what is causing the amplification?
- Based on Luminant's statements that the increase in the design force is in the range of 8% and the original design goal was to achieve D/C ratios of less than 0.9, this suggests that current D/C ratios could be close to unity. This warrants a bit more attention and detail.
- Because of the previous observation, it is my opinion that Luminant should include (quantify) this effect in their structural calculations rather than addressing as an after the fact spot check.

Milton O. Valentín, ME
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Protecting People and the Environment

Hearing Identifier: ComanchePeak_COL_Public
Email Number: 1334

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Sent Date: 4/28/2011 10:32:32 AM
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From: Woodlan, Don

Created By: Donald.Woodlan@luminant.com

Recipients:
"Monarque, Stephen" <Stephen.Monarque@nrc.gov>
Tracking Status: None
"Valentin, Milton" <Milton.Valentin@nrc.gov>
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"Galvin, Dennis" <Dennis.Galvin@nrc.gov>
Tracking Status: None

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We received the following questions as a follow-up to RAI Question 3.7.3-4:

1. Luminant should provide a technical argument justifying why the peak of the base slab ISRS necessarily bounds the peak of the basin wall ISRS

2. What are the geometry and configuration of the basin walls being considered, and what is the connection to the geometry and configuration of the base slab being considered? How are the frequencies of the walls and base slab related?

3. There are several walls in the UHSRS including external walls and internal walls that separate different rectangular regions. Luminant should identify the walls being considered and describe how the use of the base slab spectrum is conservative for each case.

4. It would be very helpful if Luminant were to provide a stronger physical argument for the use of the base slab spectrum.

5. It would be very helpful if Luminant were to provide a physical basis for why the use of the base slab spectrum is conservative.

6. Where is the base slab ISRS derived?

7. What does the 10 Hz peak in the base slab ISRS represent? That is, what is causing the amplification?

8. Based on Luminant's statements that the increase in the design force is in the range of 8% and the original design goal was to achieve D/C ratios of less than 0.9, this suggests that current D/C ratios could be close to unity. This warrants a bit more attention and detail.

9. Because of the previous observation, it is my opinion that Luminant should include (quantify) this effect in their structural calculations rather than addressing as an after the fact spot check.

Response to follow-up to RAI Question 3.7.3-4

The response to the above questions is provided below in a manner intended to provide a logical presentation of the primary line of questioning concerning the justification of the method of approach in calculating the hydrodynamic wall pressures due to vertical ground excitation. Following the main response, each question above is responded to individually.

Justification for the use of the base slab vertical spectra for calculation of hydrodynamic pressures on the tank shell can be found in standards and technical literature described below:

ASCE 4-98 (Ref. 1) Section 3.5.4.4 relates to vertical fluid response mode and Section 3.5.4.4.1 relates to hydrodynamic pressure on a tank shell due to the vertical mode. Section 3.5.4.4.1 states that:

(a) The hydrodynamic pressure, P_v, on the tank shell at depth y from the top of the fluid due to fluid response in the vertical mode may be obtained from:

$$P_v = (S_{a_v})\rho y$$

Where

ρ = fluid mass density;

S_{a_v} = vertical spectral acceleration of the tank base at the vertical fluid response mode natural frequency.

In determining the vertical spectral acceleration, the damping shall be taken as the damping of the tank shell.

(b) When determining the vertical fluid response mode natural frequency, the effect of tank shell breathing flexibility shall be considered.

Per ASCE 4-98, as described above, the hydrodynamic pressure on the tank shell due to fluid response in the vertical mode is based on vertical spectral acceleration of the tank base at the vertical fluid response mode natural frequency which is the tank shell breathing mode.

"Seismic Design and Evaluation Guidelines for the Department of Energy High-Level Waste Storage Tanks and Appurtenances" by K. Bandyopadhyay, A. Cornell, C. Constantino, R. Kennedy, C. Miller and A. Veletsos from October 1995 (Ref. 2) also calculates the pressure on the wall to be proportional to the vertical spectral acceleration of the base input motion evaluated at the breathing mode of vibration. Section 4.5 of this document relates to effects of vertical component of base motion, and Section 4.5.1 states:

> The hydrodynamic wall pressures induced by the vertical component of ground shaking are uniformly distributed in the circumferential direction and may be considered to increase from top to bottom as a quarter-sine wave. The maximum value of the pressure at a level defined by the dimensionless distance η_t is given by:
>
> $$p_v(\eta_t) = 0.8\left[\cos\frac{\pi}{2}\eta_t\right]\rho_l H_l\,(S_a)_v$$
>
> in which $(S_A)_v$ represents the spectral pseudo-acceleration of a similarly excited single-degree-of-freedom system, the natural frequency and damping of which are equal to those of the fundamental, axi-symmetric, breathing mode of vibration of the tank-liquid system.

A comparison of the pressures calculated using the ASCE 4-98 and Bandyopadhyay equations was performed considering a 1g vertical spectral acceleration and the comparison is presented in Figure 3.7.3-4A-1. The comparison shows that both methods result in similar hydrodynamic lateral pressures.

The calculated wall frequencies in the UHS basin vary by location due to the differences in wall dimensions in each cell with a minimum frequency over 4.5 Hz. These frequencies were calculated using the seismic distribution of impulsive mass. Because we have no single breathing frequency for the tank wall, but rather multiple local wall frequencies, we use the vertical peak spectral acceleration as the breathing frequency in the evaluation of the impact of increased lateral pressure on the UHS basin walls due to vertical ground motion. Use of the spectral peak is more conservative than evaluating each wall for the spectral acceleration at each wall's respective frequency. All of the external basin walls were considered in the evaluation.

Response to individual questions:

1. Luminant should provide a technical argument justifying why the peak of the base slab ISRS necessarily bounds the peak of the basin wall ISRS

    - As discussed above the calculation of hydrodynamic wall pressure is based on the vertical spectral acceleration at the base slab evaluated at the tank breathing mode of response. Since the tank walls respond at different frequencies we chose to use the maximum possible response which would occur if the breathing frequency coincided with the peak of the base slab vertical ISRS.

2. What are the geometry and configuration of the basin walls being considered, and what is the connection to the geometry and configuration of the base slab being considered? How are the frequencies of the walls and base slab related?

    - The geometry and configuration of the basin walls are shown in Figure 3KK-4 of the FSAR (Figure 3.7.3-4A-2). The basin consists of four external walls with a number of internal walls including those that supporting the pump house and cooling towers. The external walls are primarily supported on the basin slab and three sides at intersections with other walls. At the pump house and cooling tower region, some walls also have support along the top edge.

3. There are several walls in the UHSRS including external walls and internal walls that separate different rectangular regions. Luminant should identify the walls being considered and describe how the use of the base slab spectrum is conservative for each case.

    - All external basin walls were considered in the analysis. Use of the base slab spectrum is described in the main response above.

4. It would be very helpful if Luminant were to provide a stronger physical argument for the use of the base slab spectrum.

    - See main response above.

5. It would be very helpful if Luminant were to provide a physical basis for why the use of the base slab spectrum is conservative.

    - See main response above.

6. Where is the base slab ISRS derived?

    - The base slab vertical ISRS used in the analysis was calculated in the SSI analyses using the following steps:

- Perform SSI analysis for each analysis case and direction of input motion,
- SRSS of vertical ISRS from the three orthogonal input motions for each analysis case,
- Envelope of all analysis cases,
- Envelope of the four corners and center of base slab ISRS,
- Broaden entire spectra by 15% frequency shift,
- Eliminate spectral valleys.

7. What does the 10 Hz peak in the base slab ISRS represent? That is, what is causing the amplification?

    - We have not investigated the cause of the 10 Hz peak in great depth. However we notice that the pump house roof and slab frequencies are near 10 Hz and the spectra in these areas are also amplified. It is possible that the response of the pump house is amplifying motions in the base slab.

8. Based on Luminant's statements that the increase in the design force is in the range of 8% and the original design goal was to achieve D/C ratios of less than 0.9, this suggests that current D/C ratios could be close to unity. This warrants a bit more attention and detail.

    - The check performed for RAI Question 3.7.3-4 simply calculated the structural demands at each element resulting from the hydrodynamic pressure caused by vertical shaking and compared this value to the originally calculated demands. This maximum increase in demand at any location was calculated to be 8%. Significant additional calculations would be required to perform the complete recalculation including full implementation of load combinations and performing the design check at each element/section. Because the seismic load combinations use 100-40-40 spatial combination and the wall designs were primarily controlled by 100% horizontal + 40% vertical cases (when controlled by seismic) the increase will most likely be increased by 40% of 8% rather than the full 8% as assumed. We believe the additional effort is unnecessary since the calculations performed for the response are conservative by considering the maximum demand ratio, use of the peak of the spectra rather than the spectra value at the wall frequencies, and adding the demand ratio directly without consideration of load combination effects.

9. Because of the previous observation, it is my opinion that Luminant should include (quantify) this effect in their structural calculations rather than addressing as an after the fact spot check.

    - See response to Question 8.

References:

1. American Society of Civil Engineers. "Seismic Analysis of Safety-Related Nuclear Structures and Commentary." ASCE 4-98.

2. K. Bandyopadhyay, A. Cornell, C. Constantino, R. Kennedy, C. Miller and A. Veletsos. "Seismic Design and Evaluation Guidelines for the Department of Energy High-Level Waste Storage Tanks and Appurtenances." October 1995.
3. Kianoush, M.R. and J.Z. Chen. "Effect of vertical acceleration on response of concrete rectangular liquid storage tanks." Engineering Structures 28 (2006) 704-715.

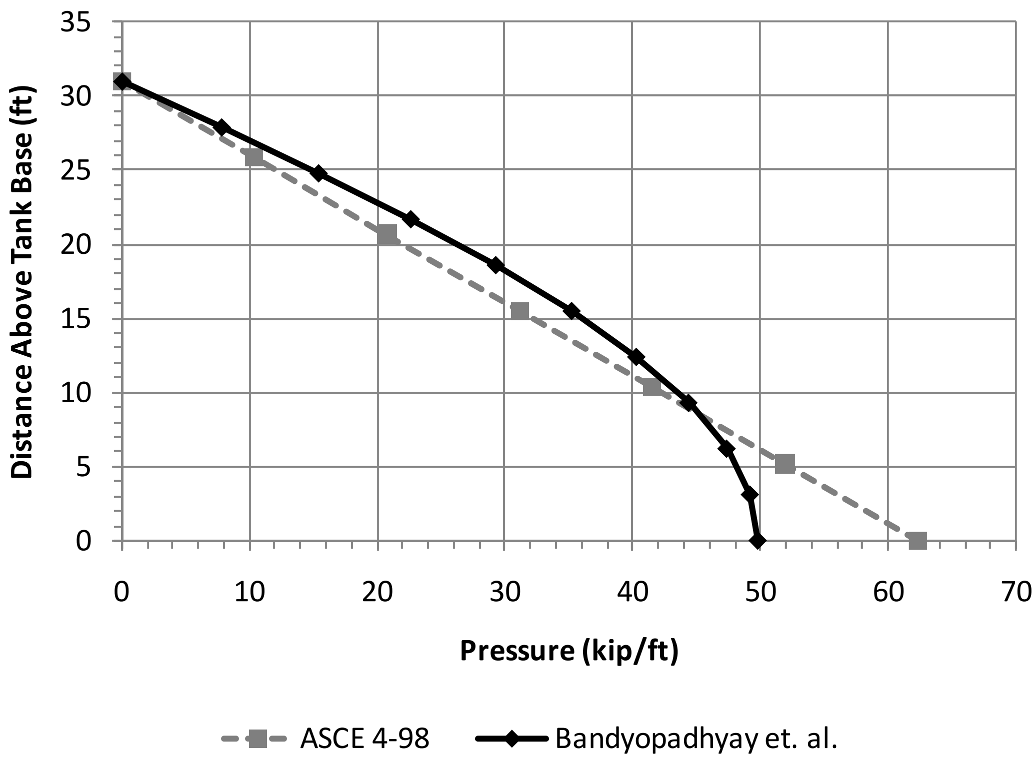

Figure 3.7.3-4A-1 – Comparison of Hydrodynamic Lateral Pressure based on ASCE 4-98 and Method Presented in Ref. 2 by Bandyopadhyay et. al. for 1g Vertical Spectral Acceleration

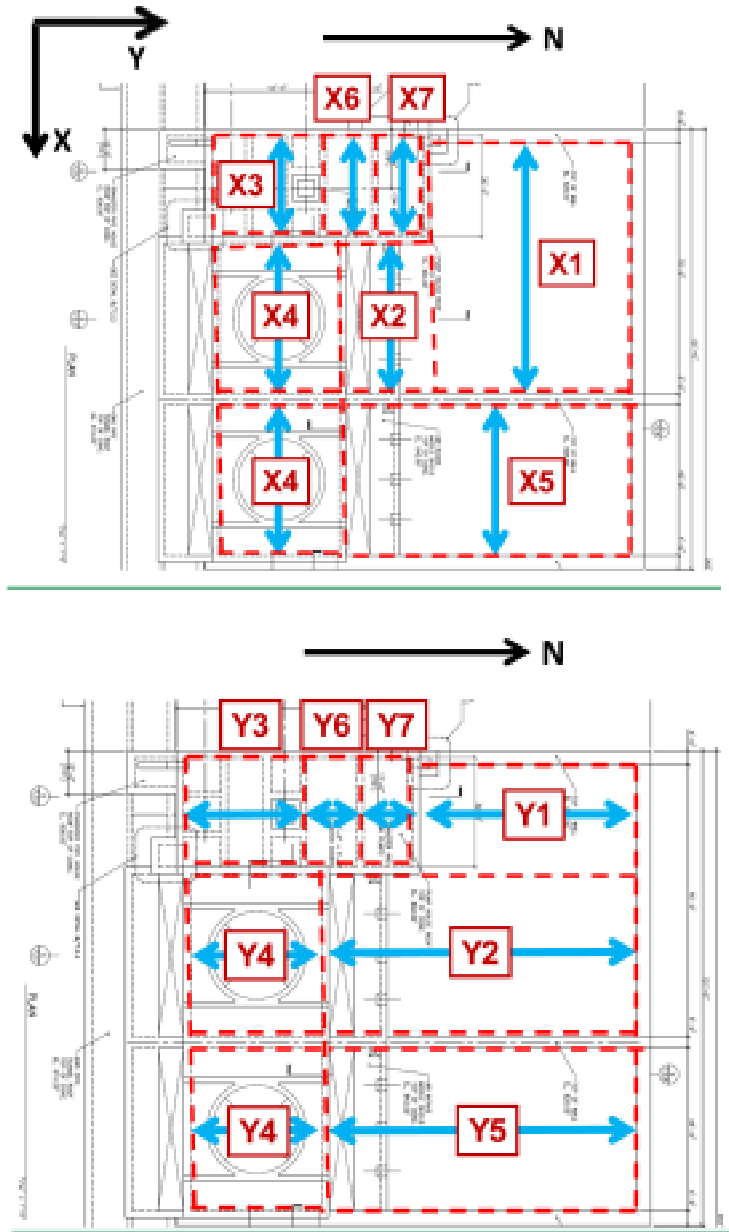

Figure 3KK-4 Rectangular Hydrodynamic Regions Used for Analysis

Figure 3.7.3-4A-2 – Rectangular Hydrodynamic Regions of the UHS (Figure 3KK-4 from FSAR)