HLWYM HEmails

From: Luis Ibarra
Sent: Thursday, May 24, 2007 10:52 AM
To: Mahendra Shah
Cc: Biswajit Dasgupta; achowdhury@swri.edu
Subject: Structural damping

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Mahendra,

I'd like your opinion about the following guidelines for structural damping before attending the technical exchange next week:

Section 3.7.1 of NUREG 0800 indicates that Reg. Guide 1.61 should be used to determine the structural damping.

Reg. Guide 1.61 indicates that reinforced concrete (RC) structures would have a percentage of critical damping ξ = 7% for safe-shutdown earthquakes (SSE), and ξ = 4% for operating-basis earthquakes (OBE).

Reg. Guide 1.61 calls NUREG/CR-6919, where it is indicated that:
"(1) If the significant stresses due to load combinations that include SSE are at least 80% of the applicable code stress limits, then use of SSE damping levels for the seismic analysis is appropriate and acceptable.
(2) If the significant stresses due to load combinations that include SSE are less than 80% of the applicable code stress limits, then using SSE damping levels may under-predict the structure's response to seismic loads. In this case, structural evaluation and development of in-structure response spectra should be based on a seismic analysis utilizing the OBE damping values specified in Table 2 [i.e., ξ = 4%].
(3) As an alternative to (2), the applicant/licensee may submit a plant-specific justification for using damping values higher than the OBE damping values specified in Table 2, but less than the SSE damping values used initially."

Based on this information, the surface facilities design for the 2000 yr return period (DBGM) should use a structural damping ξ = 4%, because according to the discussion in Appendix 7 meeting, the maximum stresses are about 60% of the elastic limit. For BDBGMs, the structural damping should be ξ = 7% as a maximum, because the stresses would be close to the elastic limit.

DOE, however, has indicated that they will use ξ = 7% for DBGMs and ξ = 10% for BDBGMs, in accordance with ASCE 43-05 where Table 3-2 indicates that for

Response Level (RL) 1, RC structures should use ξ = 4%
Response Level (RL) 2, RC structures should use ξ = 7%
Response Level (RL) 1, RC structures should use ξ = 10%

The RLs are a function of the Demand-Capacity ratio, where the total elastic demand (De) is used. Table 3-3 provides these ratios:

RL 1 has De/C ratio less than or equal to 0.5
RL 1 has De/C ratio from 0.5 to 1.0
RL 1 has De/C ratio larger than or equal to 1.0

Several comments/questions about this:

1. Not only the damping ratios, but also the De/C ranges provided by NUREG/CR-6919 and ASCE 43-05 are different.
2. DOE indicates that non-linear analyses are not needed because they are only at the brink of inelastic performance. Then, ξ = 10% may not be adequate. Note that this is debatable because ASCE 43-05 recommends this value when De/C is equal or larger than 1.0

3. ASCE 43-05 indicates in Page 12 that "if a nonlinear inelastic response analysis is performed that explicitly incorporates the hysteretic energy dissipation, Response Level 1 damping values shall be used to avoid double counting of the hysteretic energy dissipation…" If the use of the hysteretic energy dissipation factor (Fu) qualifies as "nonlinear inelastic response analysis", then DOE should use ξ = 4% for obtaining the performance for BDBGM, instead of ξ = 10%.
4. Depending on the structural frequency and seismic characteristics at the site, the difference in the damping considerations may modify the seismic demands (response spectra) up to 20-30%.
5. Even if DOE is correctly interpreting ASCE 43-05, what is the guideline that has priority in case of contradictions? In fact, you may cite other NRC documents such as NUREG/CR-0098 from Newmark and Hall, and the damping ratios and ranges of application are again different.

Also note that the presentation for the technical exchange of next week ("Seismic Design Considerations" by M.A. Denlinger) indicates in slide 10 that structural damping is in accordance with ASCE 43-05, whereas in the summary (slide 17) is stated that TIER-1 analysis methodology is consistent with NUREG 0800.

I have a few comments about soil damping that I will send you later.

Have a good day.

Luis

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From: Luis Ibarra

Created By: libarra@cnwra.swri.edu

Recipients:
"Biswajit Dasgupta" <bdasgupta@cnwra.swri.edu>
Tracking Status: None
"achowdhury@swri.edu" <achowdhury@swri.edu>
Tracking Status: None
"Mahendra Shah" <Mahendra.Shah@nrc.gov>
Tracking Status: None

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