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Mr. Goutam Bagchi
Chief, Structural Engineering Research Branch
Division of Reactor Safety Research
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Subject: Summary of Task 10/TAP A-40 June 19-20 Meeting in Bethesda

Dear Goutam:

The purpose of this letter is to summarize the topics covered and issues discussed during the course of the subject meeting. A list of attendees for each day is attached, as well as copies of the presentations made by Jim Johnson and Bob Kennedy. The purpose of the meeting was to allow Livermore's consultants to make informal presentations to the LLL core members and to members of the NRC staff, regarding their proposed recommendations for changes to the Standard Review Plan and Regulatory Guides. A brief summary of the recommendations and comments made is attached. The comments are those of consultants, LLL core members, and NRC staff members, and are included to stimulate further thought on the subject matter of interest. No attempt to identify the commentor has been made. It should be clearly understood that these recommendations do not necessarily reflect final recommendations by LLL. For the most part, the specific details regarding the implementation of these recommendations (formulas, etc.) have not been included in this summary.

If you have any questions, please feel free to call me.

Sincerely,

David W. Coats Jr.

David W. Coats, Jr.
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Enclosure
cc: see attached

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TASK 10/TAP A-40 MEETING SUMMARY

June 19th -- Soil-Structure-Interaction -- Jim Johnson*

RECOMMENDATIONS

- Direct Solution and Substructure Approaches may both be used for Soil Structure Analysis as long as they are properly applied and within the limitations discussed below.

  Performing independent analyses with each technique and enveloping the results should not be required.

- Direct Solution Method is:

  - Applicable for sites with soil layer over competent rock for the rock surface within 150 feet of the surface.

  - For a rock location greater than 150 feet:

    - Model depth must be at least 4 radii.

    - Fundamental frequency of the stratum must be well below structural frequencies of interest.

    - Consider alternate to deconvolution for defining model boundary free-field motion (e.g., Trial and error).

- Substructure Approach

  - Find foundation motion including translations and rotations.

  - Determine impedance functions. (Soil characteristics must account for variation with excitation level.)

  - Perform SSI analysis. (Frequency dependence of soil impedances properly accounted for.)

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*Jim Johnson made the presentation in the SSI area for Dr. Roesset as Dr. Roesset was unable to attend due to a prior commitment.

- <u>Specification of Seismic Design Environment</u>
    - Defined on the surface or rock.
    - Broad band spectra for firm soil sites.
    - Specific spectra for competent rock and deep soft soil sites.
    - Reductions in foundation level response spectra should be limited to a 40% reduction of the surface for all frequency ranges.
- <u>Wave Passage Effects</u>
    - Wave passage velocity is apparent velocity.
    - Alteration of translational input must be accompanied by resulting torsion and rocking.
    - Apparent wave velocity should be consistent between SSI analysis and analysis and design of buried components, etc.
- <u>Methods of Accounting for Nonlinear Soil Behavior for Design</u>
    - Consistent linear analysis accounts for primary nonlinearity.

      Determine representative material model to account for excitation level in the free field.
    - Iterative linear analysis on the coupled soil structure model. (Direct Solution Approach)

  NOTE: These two techniques are equally acceptable.

    - Nonlinear analysis should <u>not</u> be performed for design.
        - Superposition of horizontal and vertical response as determined from separate analyses is probably acceptable considering the currently available simple material models.
        - More than one time history is recommended for the analysis. Possibly separate randomly selected time histories for each variation in soil properties.
        - Models for deconvolution must be consistent for free field and soil structure interacation computation.

- Soil properties for design shall be
  - Best Estimate
  - 1.5 x (Best Estimate)
  - (Best Estimate)/1.5

  The resulting responses shall be enveloped.

- Slanted Soil Layers
  - For slanted layers up to and including 25°, horizontal layer may be assumed.
  - Above 25°, must account for coupling between horizontal and vertical DOF's in the stiffness and seismic input definition.

COMMENTS

- Relatively simple methodologies need to be established by which soil structure interaction analyses results may be checked for feasibility.
- Further investigation of the effects of structure-to-structure interaction, especially in 3-D, are needed before design conditions should be specified.
- The assumption of representing a general 3-D configuration of structures with a set of 2-D plane strain models requires further evaluation especially for deep soil profiles.
- The importance of flexible side boundaries in the direct solution approach needs to be evaluated. Also, how can flexible side boundaries be accounted for in the substructure approach?
- Need guidance on considering flexibility of the base mat.
- Some concern expressed that the uncertainties in the SSI area may not warrant any refinement of the analytical techniques.
- Perhaps the emphasis should be on using more simplified models and making parameter studies instead of attempting to produce highly complex models.
- Some concern expressed as to whether a rotational component at the foundation level is necessary.

- A 40% limit on reduction of free-field surface acceleration was proposed. Question raised as to whether a similar limit should be placed on soil modulus change during equivalent linear analysis.
- Secant modulus may preclude transmitting high frequency motion.

June 19th -- Seismic Input -- Carl Stepp

RECOMMENDATIONS

- The data base currently available in the area of seismic input does not presently warrant any significant changes to the pertinent sections of the Standard Review Plan (SRP) or the Regulatory Guides.

- SRP sections 2.5.2 and 3.7.1 describe acceptable methodologies for determining the proper seismic design ground motion input to the soil-structure system. However, because of the many revisions to these sections, they are weak and unclear. These sections should be carefully rewritten.

- The current approach to the definition of seismic input recognizes the high degree of uncertainty in our knowledge in this area. Investigations into the areas containing these uncertainties are currently underway. However, pending the results of these investigations, no changes to the SRP or Regulatory Guides is indicated.

COMMENTS

- Considering two horizontal earthquake components to be of equal magnitude is probably too conservative.

- SRP should discourage use of time-history approach and encourage response spectrum approach.

- Earthquakes have been recorded having vertical components greater than their horizontal components.

June 20th -- Structures -- Bob Kennedy

RECOMMENDATIONS

Buried Structures and Above Ground Vertical Tanks

- The Standard Review Plan (SRP) needs to provide additional guidance concerning the minimum requirements for an adequate seismic analysis and design of buried pipes, conduits, etc., and aboveground vertical tanks.

Modal Response Combinations

- The procedure for combining modal responses as given in SRP 3.7.2 should be modified to account for the inaccurate and possibly significantly unconservative results that could occur from the SRSS combination of modes having natural frequencies at which the spectral accelerations roughly return to the peak zero period acceleration.

- Special procedures for the combination of closely spaced modes are probably unwarranted. The improvement in results over the pure usage of the SRSS method is minor and does not appear to justify the added complexity. However, if closely spaced modes must receive special treatment, then one should use relative algebraic signs for individual modal responses and not absolute signs in the Double Sum method.

Simplified Inelastic Procedures for Structures

- Limited amounts of inelastic energy absorption should be allowed for the SSE level. Observations of structural response to earthquakes have clearly shown that these structures are capable of absorbing and dissipating a considerable amount of energy when strained in inelastic response beyond their elastic limit.

- The Newmark Inelastic Response Spectrum Technique is recommended if limited amounts of inelastic energy absorption are to be allowed. Studies have shown that this technique adequately predicts the inelastic response of typical structures as compared to inelastic time-history analyses.

- Allowable levels of ductility should be directly related to the safety-related function of the structure, equipment or component being considered.

Elastic Floor Spectra for Structures with Limited Inelastic Response

- Broadened elastic calculated floor spectra should be used as subsystem input for structures where the system ductility factor is limited to 1.3 or less.

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- For structures in which the system ductility factor exceeds 1.3, it is necessary to obtain both elastic and inelastic calculated floor spectra, and the design elastic floor spectra should envelope both. For the computation of the inelastic calculated elastic floor spectra with system ductility factors less than 2, it is permissible to use a simplified model of the structure which accurately reproduces the elastic response and roughly approximates the inelastic response.

- For subsystem design, it is appropriate to reduce the broadened elastic floor spectra to obtain design inelastic floor spectra using the Newmark Inelastic Response Spectrum Technique and the appropriate subsystem ductility factor.

- Load combinations, load factors, and allowable strengths are to be unchanged from those used when inelastic energy absorption capability is not included.

Direct Generation of Floor Spectra

- The Standard Review Plan should not encourage the use of time-history approaches, but should encourage use of some of the better modal response spectra techniques. The time-history approach should continue to be allowed because it is necessary for nonlinear analyses.

- Floor response spectra should be computed directly from ground response spectra without time-history analysis. It has been observed that different artificial time histories, both of which result in response spectra which adequately envelope the Regulatory Guide 1.60 response spectra, can lead to floor spectra which may differ by a factor of 2 or more. The generating of floor response spectra from ground response spectra would eliminate artificial conservatism and large dispersion in the results.

- It is recommended that the Standard Review Plan allow the use of probabilistic generated floor spectra corresponding to the 95% confidence bound of an 84% nonexceedance probability in lieu of deterministic floor spectra. Such spectra will be flatter than current spectra with the valleys raised and peaks lowered.

Number of Earthquake Cycles During Plant Life

- Recent studies have shown that it appears that the typical OBE has only a small probability of occurance during the plant life. Therefore, it is recommended the Standard Review Plan require only two OBE's to be assumed to occur during the plant life instead of the current five OBE's.

COMMENTS

Buried Structures

- When discussing buried structures, the SRP talks about inertial effects when it should be talking about displacement effects.
- Strain effects are a function of the type of wave producing the strains. The SRP needs to give guidance in this area.
- SRP should give guidance in determining apparent shear wave velocities.
- Need to determine where effective velocities should be defined; i.e., at depth, at surface, etc.
- SRP needs to give guidance in determining wave lengths and reductions for friction effects.
- Must account for relative displacements between anchor points.
- Design criteria should be strain limited. (i.e., secondary stress levels should be allowed)
- Buried structures need to be designed with ductility in mind so that they are capable of accomodating the induced strains that will be seen.

Above Ground Tanks

- Housner procedure for design can have serious problems if rigid tank walls are assumed for impulsive modes.
- Good results can be obtained using the Housner approach as long as the spectral acceleration is calculated using the natural frequency of the tank.
- The API code has good procedures for determining vertical buckling of tanks.
- Internal tank roof supports must be designed for fluid-structure interaction.
- SSI effects on tanks probably does not need to be done as this usually results in reduced force levels. Therefore, the use of a rigid base for seismic analysis of tanks is conservative.
- SRP 3.7.2 and 3.7.3 should be combined into one 3.7.2 and 3.7.3 should be devoted to "special structures."

Pile Foundations

- Pile foundations should be covered on a case-by-case basis.

Inelastic Structural Response

- The SRP would have to make a very clear definition of ductility factor.
- Could only allow simplified nonlinear design for low values of inelasticity.
- Equipment will see less response if structure is allowed to respond inelastically.
- Structures that are theoretically responding in the elastic range are actually undergoing some low level of inelastic response because of the actual nonlinear nature of the structural materials and structural configurations.
- No special requirements would need to be ade for structures employing a system ductility factor of 1.3 or less as current design practice would accomodate this ductility level.
- Damping values used with the reduced spectra should be elastic damping levels for the structural materials at or near their yield point.
- Reducing entire spectrum reduces forces in <u>all</u> members - whether they go inelastic or not -- could be nonconservative for non-ductile members; e.g., columns.
- If system ductility is used, one doesn't really know the member level ductility demand.
- A minimum ductility capacity should be specified for all new structures.
- An alternative method was proposed for utilizing member ductility demand.

June 20th -- Equipment and Components -- Bob Cloud

RECOMMENDATIONS

- The conservatisms inherent in the current seismic design process can be organized into three major categories or phases. These categories are:

1) "Design Earthquake Margin" This incorporated the conservatisms inherent in the definition of the ground motion input. The "g" levels, spectra, and time-histories are chosen so that a certain positive margin exists between the magnitude of the design basis events and the seismic events expected to occur at the site during the facility's lifetime. This margin consists of conservatisms in the "g" level, frequency content, and duration of strong ground motion or overall energy level.

2) "Calculation Margin" This margin is inherent in the current procedures for establishing a structual configuration and the techniques used to perform an analysis of this configuration to determine if the response of the element or system to the design earthquake is satisfactory according to the design criteria. In practice, the process is lengthy and complicated. In determining the response of the basic plant elements, buildings, piping, and equipment, certain additional margins are developed.

3) "Design Criteria Margin" This conservatism results from the various allowable stresses and assumptions used in the determination of material properties. In addition to these mainly strength related criteria there are other criteria related to operability that contain various levels of safety margins.

- The continued retention of the conservatisms inherent in the category of "Calculational Margins" is no longer necessary due to the advances in technology and the accumulated experience of recent years.

However, the conservatisms in the categories of "Design Earthquake" and Design Criteria Margin" should be retained.

<u>COMMENTS</u>

- Past seismic events at conventional power plants have shown little or no structural or equipment damage for seismic levels equivalent to the design basis earthquake.

- In many cases it may be a disadvantage to stiffen or strengthen piping systems.

- Need to get a design philosophy of having a specified overall factor of safety.

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Task 10/TAP A-40 Meeting
June 19, 1979

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Task 10/TAP A-40 Meeting
June 20, 1979

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Dave Coats	LLL
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