Public Comments on Draft SRP Sections 3.7.2, 3.7.3, 3.8.1, 3.8.3, 3.8.4, and 3.8.5
Prepared 7-15-13

Comment	Proposed Resolution	NRC Staff Resolution
NEI Comments:		
1. General Comment for 3.7.1 and 3.7.2 Site amplification analysis based on Random Vibration Theory (RVT) has widely been used for the past several years (RG 1.208 already permits use of RVT-based site response analysis). This approach provides a significant advantage in that it obviates the need for time-history representation of the design spectrum. This advantage can be further exploited by performing RVT-based SSI analysis, which is significant since it provides a stable mean solution for SSI response, something that has become a concern for time-history based approach (whereby multiple time-histories are warranted). The importance and benefits of RVT-based approach are recognized in the industry, which is reflected by the fact that ASCE 4-13 (due to be issued later this year) permits use of RVT-based approach for both site amplification analysis and SSI analysis.	SRP Sections 3.7.1 and 3.7.2 should include language that recognizes the applicability of RVT-based approach for SSI analysis.	The staff agrees with the resolution; and therefore, SRP Section 3.7.2 II.4 has been revised to include the following: "Methods (such as use of random vibration theory, etc.) other than those described above may also be used for SSI analyses. The acceptability of these methods will be determined on a case-by-case basis review."
2. Section 3.7.2 I (Areas of Review), First Paragraph [p. 3.7.2-1] Title is missing	"1. Seismic Analysis Methods" should be added to the beginning of the paragraph that starts on this page.	The staff agrees with the comment; and therefore, SRP Section 3.7.2 I has been revised as follows: "1. <u>Seismic Analysis Methods</u>. For all seismic Category I structures..."

3. Section 3.7.2 I (Areas of Review, Development of In-structure Response Spectra) [p. 3.7.2-3] Recent studies have shown that RVT can provide a very stable in-structure response spectra by avoiding issues related to the adequacy of the time histories.	Add a statement that RVT approach will be reviewed on a case by case basis.	This comment has been addressed in the NRC staff resolution to NEI Comment No. 1.
4. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Seismic Analysis Methods, Dynamic Analysis Methods), Item i. [p. 3.7.2-8] This paragraph lists acceptable methods of analysis but does not include RVT .	Include RVT as an alternate method.	This comment has been addressed in the NRC staff resolution to NEI Comment No. 1.
5. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Procedures Used for Analytical Modeling, Decoupling Criteria for Subsystems) [p. 3.7.2-10] There appears to be a typo in criterion ii. (“0.8 ≥ Rf ≥ 1.25” should be “0.8 ≤ Rf ≤ 1.25”).	Change “0.8 ≥ Rf ≥ 1.25” to “0.8 ≤ Rf ≤ 1.25”	The staff does not agree with the proposed resolution. The SRP is correct, as written: “0.8 ≥ Rf ≥ 1.25”. This means that Rf should be less than 0.8 or more than 1.25. This is appropriate for decoupling because it ensures that the frequency of the supported subsystem (e.g., cable tray system or piece of equipment is sufficiently below or sufficiently above the dominant frequency of the support to the subsystem.
6. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Soil-Structure Interaction) [p. 3.7.2-15] At the top of p. 3.7.2-15, it says, “If the ratio is less than 80%, then the effect of the nonlinearity due to the foundation uplift should be assessed, and if found to be important, then it should be accounted for in the seismic design, which is reviewed on a case-by-case basis.” The	The SRP should be expanded to describe in more detail what is considered “important.”	This issue has been addressed in the NRC staff resolution to MHI/MNES Comment No.1 below.

SRP should be expanded to describe in more detail what is considered "important." Otherwise, it becomes difficult to use this part of the SRP since it is not clear what would be acceptable to the NRC.		
7. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Soil-Structure Interaction, Input Ground Motion), Item ii. [p. 3.7.2-16] It is not clear why site specific design motion should be developed only for the ground surface level. The concept of FIRS was developed to have design motion at the foundation level. See DC/COL-ISG-017.	Add the option to develop the site-specific motion either at the surface or foundation level and emphasize the consistency of design motion generation with its application to SSI analysis.	The staff agrees with the comment; and therefore, has revised Section 3.7.2 II.4.C – Input Ground Motion, by replacing paragraphs i and ii with the following paragraph i: "For structures with either surface or shallow embedded foundations, the seismic input motions to the SSI analyses can be placed at the free ground surface or at the foundation level. For embedded structures, the seismic input should be specified at the foundation level as FIRS. In developing the corresponding ground motions at the surface, the potential effects of soft soil layers and/or compacted backfill layers need to be considered."
8. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Soil-Structure Interaction, Input Ground Motion, Specific Guidelines for SSI Analysis), Fourth Bullet [p. 3.7.2-17] FIRS is more appropriate than GMRS for the comparison discussed in this bullet.	Change GMRS to FIRS in this bullet.	The staff agrees with the proposed change; and therefore, has revised SRP Section 3.7.2 II.4.C - Input Ground Motion, Specific Guidelines for SSI Analysis, fourth bullet, as follows: "For a COL application referencing a standard plant design, where the site-specific FIRS are enveloped by the standard plant CSDRS determined at the foundation level, the SSI evaluations are addressed in the standard plant design."
9. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Soil-Structure Interaction, Input Ground Motion,	Revise this bullet to acknowledge that it may be demonstrated	SRP 3.7.1 provide adequate guidance for both defining and developing FIRS to be use in seismic analysis. Regardless of methods and associated

Specific Guidelines for SSI Analysis), Eighth Bullet [p. 3.7.2-19] The direct approach requires input motion in the form of displacement, velocities, or acceleration at the boundary of the model.	that the foundation level motion, far from the structure, as calculated by the direct approach envelops the FIRS typically obtained from 1D site response analysis.	models used, it is up to the applicant to demonstrate that the free-field outcrop motion at the foundation level is consistent with the FIRS. The staff reviews the information on a case-by-case-basis.
10. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Soil-Structure Interaction, Input Ground Motion, Specific Guidelines for SSI Analysis) [pp. 3.7.2-20 and 3.7.2-21] The recommendations for checking the frequencies of the excavated soil volume are not necessary. Please note the excavated soil volume under fixed boundary condition is not relevant to the excavated soil volume in the SSI model. The frequencies under fixed base condition may be totally absent in the SSI solution, making such a test much less relevant. The checking should be limited to careful inspection of transfer functions for the responses of interest supplemented by SSI analysis using a half or quarter model with the direct method or independent verification. These two measures will be adequate to prevent spurious peaks from the use of the SM. Furthermore, the effect of spurious peaks on design quantities must be assessed. Transfer function is a very sensitive measure of response but it is never used for design. ISRS and seismic member forces are used for design.	Revise these pages to allow use of the design quantities to justify the accuracy of the solution and avoid unnecessary frequency calculation of the excavated soil.	The staff does not agree with the comment that computing the fundamental frequencies of the excavated soil volume is unnecessary. Recent DOE-sponsored analytical work (Mertz et al., 2011) has identified a strong correlation between (a) the fundamental frequencies of the excavated soil volume, and (b) the frequencies at which spurious spikes begin to appear in the transfer functions computed using the SASSI-SM. This information is summarized in the Technical Rationale document. The intent of the recommendation is to guide the review of transfer functions computed using the SASSI-SM, in order to identify the presence of spurious spikes in cases where it is not possible to perform direct comparisons with transfer functions computed using the SASSI-DM (or FVM). In these cases, it is important to have an estimate of the frequencies at which these spikes might begin appear. It should be noted that the fundamental frequencies of the excavated soil volume can be computed using any general purpose finite element code.

		The SRP guidance already indicates that, as suggested by NEI, computer models of reduced size can be used to perform direct comparisons between the SASSI-SM and SASSI-DM solutions, which can then be extrapolated to the full-scale model. The staff agrees that transfer functions are sensitive measures of response that are not used directly in design. However, it is this sensitivity that makes it possible to visually detect the spurious spikes if they occur. The adequacy of the solution is determined by reviewing the seismic response; i.e., transfer functions as well as ISRS.
11. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Soil-Structure Interaction, Input Ground Motion, Specific Guidelines for SSI Analysis) [p. 3.7.2-20] The results of subtraction method or extended subtraction method can be independently verified per the direct approach by using alternate computer programs with identical soil, motion, and structural model parameters in lieu of using smaller scale representative models. The direct approach is a more complete and independent method of verification, since the alternate computer program can solve the SSI problem directly, without using a sub-structuring approach. Use of the SASSI sub-structuring direct method to verify SASSI subtraction method is computationally exhaustive and provides for a less accurate verification compared with using a true direct solution approach to perform verification.	Acknowledge in this Section that independent verification using a direct approach provides a more accurate benchmark for verification of the sub-structuring subtraction solution approach.	Applicants can utilize alternative analytical methods to independently verify the use of sub-structuring approach. The staff reviews the analysis methods and results on a case-by-case basis.

12. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Soil-Structure Interaction, Input Ground Motion, Specific Guidelines for SSI Analysis) [p. 3.7.2-21, Last Paragraph] The limits on maximum reductions allowed due to incoherency are specified without explaining how these values were established. As discussed in DC/COL-ISG-01, two separate computer programs with entirely different formulations have used the same verified ground motion incoherency model resulting in very close SSI responses for the same SSI model that shows the reduction may be much more than 30% due to incoherency effects.	Please provide the basis for limiting the reductions allowed due to incoherency or cite a reference.	Based on the staff's assessment of the initial implementation of ISG-01, which included independent confirmatory analysis conducted by the staff, the staff determined that a wide disparity in results could be achieved by different analysis agents, both ostensibly following ISG-01. The benchmark problem used to evaluate the two analysis methods accepted in ISG-01 is an idealized case. Review of the benchmark results indicated a trend in reduction which is similar to the limitations proposed in the SRP update. For the idealized benchmark case, local reductions up to 50% were obtained using a modified SASSI code. Until there is a sufficient body of data from implementation of ISG-01 for new reactor design, the staff believes that limiting the maximum reduction to 30% is prudent, in order to account for uncertainty. In the future, after greater confidence in the methodology is attained, the 30% limitation can be re-visited. The staff also notes that reductions greater than 30% can be identified, if the applicant has sufficient documented quantitative information supporting the greater reduction. The staff will review such submittals in sufficient detail, potentially including independent confirmatory analysis conducted by the staff, to establish confidence that the greater reductions are technically justified.
13. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Soil-Structure Interaction, Input Ground Motion, Specific Guidelines for SSI Analysis) [p. 3.7.2-21]	Include a statement to make it clear that an incoherency analysis is optional rather than required.	The SRP criteria are intended to provide guidance if incoherency effects are considered, which is reflected in SRP Section 3.7.2 II.4 - Specific Guidelines for SSI Analysis (e.g., "If the effect of incoherent ground motion is used to reduce the

Performance of an incoherency SSI analysis should be optional rather than required.		high frequency response...”). Therefore, the use of incoherency in SSI analysis is optional.
14. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Soil-Structure Interaction, Input Ground Motion, Specific Guidelines for SSI Analysis) [p. 3.7.2-21, Second Paragraph] This paragraph states that a larger reduction due to incoherency may be acceptable if justified. It would be helpful for this Section to include a reference to one or more examples of acceptable justification for larger reductions.	Please provide a reference for one or more example cases that includes the justification.	This comment has been addressed in the NRC staff resolution to NEI Comment No. 23.
15. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Development of In-Structure Response Spectra) [p. 3.7.2-23] The use of RVT should be allowed for generation of ISRS.	Expand the discussion to allow RVT to be used for generating ISRS.	This comment has been addressed in the NRC staff resolution to NEI Comment No. 1.
16. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Interaction of Non-Category I Structures with Category I SSCs) [p. 3.7.2-24] Item C should be expanded to clearly specify that for II/I evaluations, the design of non-Category I structures can use site-specific SSE loads.	Revise Item C to clearly specify that for II/I evaluations, the design of non-Category I structures can use site-specific SSE loads.	For structures that are not part of the DC application, the COL applicant can address the II/I issue using site-specific SSE loads. However the DC should provide a COL Information Item to ensure that the II/I issue will be adequately addressed by licensees.
17. Section 3.7.2 II (Acceptance Criteria, SRP Acceptance Criteria, Methods Used to Account for Torsional Effects) [p. 3.7.2-26]	Cite a reference for the basis of requiring accidental torsion if the dynamic model is capable of capturing	Consideration of accidental torsion effects has been standard practice in the structural engineering community for decades (nuclear and non-nuclear). Even when an adequate structural model is developed that accounts for stiffness and mass

It is not clear why accidental torsion is required for cases where an adequate structural model is developed that accounts for stiffness and mass distribution in the structure.	the torsional response.	distribution in the structure, there are always uncertainties associated with the location of the center of mass or potentially changes that may be made to the structure in the future, which is the source of the accidental eccentricity, and which have impact on the shear forces required in design.
18. Section 3.7.2.II (Acceptance Criteria, SRP Acceptance Criteria, Analysis Procedure for Damping) [pp. 3.7.2-26 and 3.7.2-27] The definitions for K and M should use symbols consistent with those in the equations.	Use K and M with bars over the top of the letters, not underlined.	The staff agrees with the proposed resolution. In the Draft Rev. 4 update to SRP 3.7.2, bars over the top of K and M were inadvertently changed to underlines. This has been corrected in the final SRP 3.7.2, Rev. 4.
19. Section 3.7.3 II (Acceptance Criteria, SRP Acceptance Criteria, Basis for Selection of Frequencies) [Page 3.7.3-5] In the draft Revision 4, the first sentence has been changed from "…less than ½ or more than twice…" to "…less than two or more than twice…" This appears to be a typo that should be corrected.	Change "two" back to "½."	The staff agrees with the comment. In the Draft Rev. 4 update to SRP 3.7.3, "1/2" was inadvertently changed to "two." This has been corrected in the final SRP 3.7.3, Rev. 4.
20. Section 3.8.3 II (Areas of Review, Loads and Loading Combinations) [p. 3.8.3-8] Loads induced by the proposed construction sequence and differential settlements may not be applicable to small modular reactors where the containment and its internal structures are fabricated in factory-controlled conditions offsite and the containment is not placed in the building until the foundation and walls are in place.	Applicability of this section for small modular reactors should be clarified.	This comment has been addressed in the NRC staff resolution to NEI Comment No.35.

21. Section 3.8.4 II (Acceptance Criteria, SRP Acceptance Criteria, Design and Analysis Procedures) Subsection H [p. 3.8.4-12] *[This NEI comment is also applicable to Section 3.8.1 II (Acceptance Criteria, SRP Acceptance Criteria, Design and Analysis Procedures) Subsection E (p. 3.8.1-14)]* The second method involves direct determination of dynamic soil pressure from SSI/FEM analysis. This approach is more accurate than the Wood method when adequately detailed SSI finite element model is used (the results from SSI/FEM analysis are more realistic since they account for the timing effect and spatial variation). Since the main purpose of seismic earth pressure determination is to use it as a load to calculate the design forces and moments on embedded walls, an even better advantage of the SSI/FEM analysis can be realized by directly harvesting the seismic-induced forces in the walls from the SSI analysis. This avoids two-step analysis approach of computing maximum seismic soil pressure and the follow up structural analysis. Also, the results from SSI/FEM analysis are more realistic since they account for the timing effect. The member forces should be computed for the range of soil profiles used in the SSI analysis with proper consideration of soil-wall separation.	Rather than using SSI/FEM analysis to just determine the dynamic soil pressure, please consider acknowledging that such analysis can directly provide the wall member forces considering the range of SSI soil profiles for design of the walls.	The staff agrees with the observation; however, typical SSI finite element analysis are based on using structural models that may not be sufficiently detailed to capture the member forces for use in design. In addition, the current design practice is to design the foundation walls for soil pressures calculated using the simplified methods and SSI/FEM analyses.
22. Section 3.8.4 II (Acceptance Criteria, SRP Acceptance Criteria, Design and Analysis Procedures) Subsection H [p. 3.8.4-12] *[This NEI comment is also applicable to Section 3.8.1 II (Acceptance Criteria, SRP Acceptance Criteria, Design and*	Expand the discussion to include the circumstances under which calculation of relative displacement dependent passive	This comment has been addressed in the NRC staff resolution to MHI/MNES Comment No. 4.

Analysis Procedures) Subsection E (p. 3.8.1-14)] It is not clear why the third method for passive pressure should be used. It is understood that if passive pressure is used for stability analysis, part of the passive pressure mobilized must be calculated and used for design of the wall. However, for cases where stability does not require mobilizing the passive soil pressure, the calculation and use of passive pressure is not clear.	soil pressure should be performed for wall design.	
23. Section 3.8.4 II (Acceptance Criteria, SRP Acceptance Criteria, Design and Analysis Procedures) Subsection H [p. 3.8.4-12] *[This NEI comment is also applicable to Section 3.8.1 II (Acceptance Criteria, SRP Acceptance Criteria, Design and Analysis Procedures) Subsection E (p. 3.8.1-14)]* The revised SRP on the subject of seismic soil pressure is too complex and the road map for the designer is confusing. The need for use of three methods has not been clearly explained.	Please consider revising this section to clearly explain the requirements if calculation of seismic soil pressure is needed and how it should be obtained in the following situations: (1) when an adequate SSI/FEM model is used, (2) when the SSI model is not refined enough such that the applicable method needs to be used, and (3) when the soil's (relative displacement dependent) passive resistance is relied upon for stability against seismic loads.	SRP Section 3.8.4, along with the Technical Rationale document in the NRC ADAMS system (ML13042A173), provide guidance on how to calculate soil pressures for the three cases described in SRP subsection 3.8.4.II 4.H. Both documents also provide additional references such as ASCE 4-98, Report by Wood (1973), and SRP Section 3.7.2. All three cases should be analyzed and these are reviewed by the NRC staff on a case-by-case basis.

24. Section 3.8.5 II (Acceptance Criteria, SRP Acceptance Criteria, Design and Analysis Procedures) [p. 3.8.5-10] Item B was enhanced guidance to evaluate sliding and overturning. However, foundation overturning may not be possible for structures in some small modular reactor designs.	This section should be revised to clarify the applicability of the criteria for small modular reactor designs.	The staff agrees with the observation that foundation overturning may not be possible for structures in some small modular reactor designs. On that basis, it should not be difficult to justify meeting the acceptance criteria. Additionally, the NRC staff has developed guidance for reviewing certain SMR designs (e.g. mPower Design Specific Review Standard (DSRS), ADAMS Accession No. ML13088A252).
MHI/MNES Comments:		
1. 3.7.2 II.4, Pg. 15; SRP Statement: “Linear SSI analysis methods are acceptable if the ground contact ratio is equal to or greater than 80 percent. The ground contact ratio can be calculated from the linear SSI analysis using the minimum basemat area that remains in compression with the soil. If the ratio is less than 80 percent, then the effect of the nonlinearity due to the foundation uplift should be assessed, and if found important, then it should be accounted for in the seismic design, which is reviewed on a case-by-case basis.”	The requirement of "it should be accounted for in the seismic design" and “if found important" are too vague. The specific aspects of the uplift effect on the design should be specified and within the ability of current analysis and design techniques to accurately compute.	The staff agrees; and therefore, SRP 3.7.2 will be revised as follows: “If the ratio is less than 80%, then the effect of the nonlinearity due to the foundation uplift should be evaluated. If the uplift effect on structural responses (e.g., in-structure response spectra, member forces, soil bearing pressure, and building displacements, etc.) is found to be significant (e.g., an increase in response of more than 10%), then the uplift effect should be accounted for in the seismic design, which is reviewed on a case-by-case basis.”
2. 3.7.2 II.4, Pg. 17; Specific Guidance for SSI Analysis. SRP Statement: “For a DC application, the postulated site profiles to be used in the seismic SSI analysis are defined. The CSDRS should be shown to be appropriate for these postulated site profiles in frequency content by demonstrating that the frequencies for the amplified portion of the CSDRS are		To respond to the first question, it is not the staff’s intention to request the development of multiple CSDRSs (and related time histories for SSI analyses) for multiple soil conditions. The staff is proposing that there be consistency between the applicant-postulated generic soil profiles and the applicant-postulated CSDRS, such that the SSI analyses are capable of predicting the amplification

consistent with the site profile column frequencies. Otherwise, the postulated site profiles will not be able to propagate the CSDRS in the SSI analysis, and thereby, will not subject the SSCs to the amplified response over the frequency range of interest to the SSI." Is it the intention to request the development of multiple CSDRSs (and related time histories for SSI analyses) for multiple soil conditions vs. one CSDRS that envelops the CSDRSs for multiple soil conditions? If the DC applicant requires the COLA applicant to confirm the design via a site specific SSI analysis, the need to tie a specific soil profile to a specific CSDRS is not needed.		of the ground motion in the structure, over the frequency range of interest. This consistency should be observed regardless of the requirements for the COL applicant to perform SSI analyses. To respond to the second question, if the DC applicant requires the COL applicant to conduct site-specific SSI analysis in order to confirm the adequacy of the standard design at the COL applicant's site, the site-specific SSI analysis should be performed by the COL applicant based on the site GMRS and associated site profiles.
3. 3.7.2 DOC II.8, Pg. 45; Description of Changes. SRP Statement: "Enhanced SRP Section 3.7.2 11.8 "Interaction of Non-Category I Structures with Category I SSCs" by revising acceptance criteria related to Criterion C. The technical rationale for this change is as follows. The objective of Criterion C is to demonstrate that failure under SSE conditions will be prevented. What constitutes "failure" is dependent on the proximity of the non-Category I structure to Category I SSCs. As an example, for a non-Category I structure in proximity to a Category I structure, the absolute sum of the seismic displacements of the two structures needs to be less than the as-designed gap between the structures for the entire height of the structures, in order to satisfy criterion C. If the structures are in *very close proximity*, it may be	The dimensional statements highlighted are vague. Clarifications to the acceptable distances for eliminating the application of Category I structural design criteria to non-Category I structures should be provided.	The updated guidance is intended to provide a graded approach to addressing the II/I interaction in Criterion C. Depending on the design gaps between the non-seismic Category I structure and seismic Category I SSCs, the applicant can use a range of analysis methods (from elastic to limited inelastic) to demonstrate the lack of physical interactions. The selection of the methods will be situation dependent, and therefore, the staff will review all Criterion C evaluations on a case-by-case basis.

necessary to apply Category I structural design criteria to the non-Category I structure, in order to satisfy Criterion C. If there is an *appreciable gap* between the two structures, then a relaxation of Category I structural design criteria may be appropriate, provided it can be demonstrated that (1) the non-Category I structure is in a stable limit state (no gross failure), and (2) the *as-designed gap (considering construction tolerances) between the structures is large enough* to accommodate the absolute sum of the seismic displacements of the two structures. The ASCE 43-05 standard presents a graded approach to design/analysis of structures for loading combinations that include seismic loads. In accordance with ASCE 43-05, nuclear seismic Category I structures require the most stringent design criteria; namely, a linear elastic limit state. This is consistent with NRC guidance for design/analysis of Category I structures. ASCE 43-05 also addresses design/analysis of structures of less critical functions, allowing response beyond the elastic limit state, to a safe and predictable inelastic limit state. Such an approach is potentially applicable to satisfying Approach C, where there is *sufficient gap* to accommodate increased displacement of the non-Category I structure. [MHI Emphasis added]		
4. 3.8.4 II.4.H, Pg. 11; Design and Analysis Procedures. SRP Statement: "Consideration of dynamic lateral soil pressures on embedded walls is acceptable if the lateral earth pressure loads are evaluated for the governing of the following three cases. These are (1) lateral earth pressure equal to the sum of the static earth pressure plus the dynamic earth pressure calculated in accordance with ASCE 4-98, Section	If this methodology is to be used, there should two bounds on the "effective" pressure, a lower bound value to use for the computation of sliding and an upper bound value to use for the design of the	The staff agrees that for soil pressure calculations to be used in the design of the foundation walls, an upper bound soil pressure should be used. That is why the SRP indicates that the governing (i.e., highest) pressure loads should be used. However, the staff does not agree to require that it include the full passive pressure because in some cases that might be too conservative. The applicant could, if needed, use the partial passive pressure that develops rather than the full passive

3.5.3.2; (2) lateral earth pressure equal to the sum of the static earth pressure plus the dynamic earth pressure calculated using an embedded SSI/FEM analysis model; and (3) lateral earth pressure equal to the fraction of the passive earth pressure that is effectively mobilized, which is dependent on the relative magnitude of the wall displacements against the soil that may occur for a given wall configuration. For case (3), the analysis should include, as a minimum, the fraction of the passive earth pressure assumed in the stability calculations performed in accordance with SRP Section 3.8.5." Regarding the third case, we do not believe that there is an acceptably accurate methodology to compute the "fraction of the passive earth pressure that is effectively mobilized."	walls. An easier and more conservative methodology is to use the envelope of the full passive pressure profile and Wood's pressure profile for the design of the wall, and to use no passive pressure for the calculation of the sliding displacements.	pressure. Also, all three cases should be included, not only the passive pressure profile and the pressure profile using the method in ASCE 4-98, Section 3.5.3.2, par. (2) (referred to as the Wood method) indicated in the proposed resolution. This is needed because under some conditions case (2), corresponding to the lateral earth pressure equal to the sum of the static earth pressure plus the dynamic earth pressure calculated using an embedded SSI/FEM analysis model, may result in higher pressures. Similarly, for evaluation of sliding stability, it might be too conservative to require that no passive pressure be used. In reality there would be some soil lateral resisting pressure (partial or full) developed which can contribute to sliding resistance.
ARES Comments:		
1. Draft Revision 4, SRP 3.7.2 II.4 (page 3.7.2-20), in the section of the criteria for "Half-Space or Substructure Solution Technique", (1), uses the terminology "Direct Method (DM)." The DM terminology can be confused with the terminology mostly used in classical text books or commonly understood by the engineering community. "Direct Method" implies that the entire soil-structural system is modeled and analyzed in a single step such as modeling in FLUSH, DYNA3D (LSDYNA), ANSIS, ADINA, ABCUS, etc. However, the SASSI's option of considering full interaction nodes within the excavated soil volume on calculation of impedance functions is a flexible volume method (FVM). It is still the sub-structuring method and not	The most appropriate terminology should be the original terminology of FVM.	To clarify the use of the DM method, the staff has revised the paragraph (1) as follows: "In the SSI analysis of embedded structures, some computer implementations of the substructure approach use two alternative methods to model the excavated soil volume: (1) The direct method (DM) in which the foundation impedance is calculated for the free field at all nodes of the excavated soil volume that is discretized into finite elements. These nodes, termed "interaction nodes," connect the excavated soil volume and the free field soil system to ensure

a direct method.		compatible motions. DM is also referred to as the flexible volume method (FVM) in frequency domain solutions."
2. Draft 3.7.2 II.4 (page 3.7.2-20) (2) , the current draft states as follows: "(2) The Subtraction Method (SM), in which a simplification is made such that only the nodes on the outer boundaries of the excavated soil volume are treated as interaction nodes. This simplification reduces the computational effort needed for solving large problems typically encountered in NPP applications. However, because the interior nodes are not connected to the free-field system, the excavated soil volume may not have compatible motions with the part of free-field being replaced, especially at frequencies higher than the fundamental frequency of the excavated soil volume. This may lead to limitations in the application of the SM and potential errors if the method is not implemented appropriately." <u>Rationale for change</u>: In fact, the interior nodes are all connected in the soil model of the free field system but the nodes were not assigned to have compliance functions calculated. Also, it is easier to understand to use the compatibility of displacement since it was used in the original formulation of the flexible volume method and other methods. Due to the numerical difference in deriving the impedance matrix from free field point load solution and the direct formulation of dynamic stiffness matrix of the excavated soil model, the SM can only provide acceptable impedance solutions in a very low frequency range. The valid frequency limit of the SM is primarily related to the size of the foundation of the structure, the shear wave velocity of the supporting soils, and how the finite element	ARES Suggests to modify current draft writing to the writing below: "(2) The Subtraction Method (SM), in which a simplification is made such that only the nodes on the outer boundaries of the excavated soil volume are treated as interaction nodes. This simplification reduces the computational effort needed for solving large problems typically encountered in NPP applications. However, because the interior nodes are not treated as interaction nodes, the compatibility of displacements is no longer imposed at every interaction nodes in the excavated volume. This may lead to	The staff agrees with the proposed resolution; and therefore, has revised SRP Section 3.7.2 II.4.C - Input Ground Motion, Specific Guidelines for SSI Analysis, as follows: "(2) The Subtraction Method (SM), in which a simplification is made such that only the nodes on the outer boundaries of the excavated soil volume are treated as interaction nodes. This simplification reduces the computational effort needed for solving large problems typically encountered in NPP applications. However, because the interior nodes are not treated as interaction nodes, the compatibility of displacements is no longer imposed at every interaction nodes in the excavated volume. This may lead to limitations in the applications of the SM and potential errors induced in computed foundation compliance functions as well as transfer functions."

sizes of the excavated soil volume is modeled but is not related to the fundamental frequencies of the excavated soil volume itself. The last sentence of the paragraph under the section on page 3.7.2-20 of the draft version, "is not implemented properly", has been deleted since the main problems are caused by improperly modeling of the interaction nodes but should not be caused by the improper implementation of the SASSI code.	limitations in the applications of the SM and potential errors induced in computed foundation compliance functions as well as transfer functions."	
3. Page 3.7.2 – 20, Current Draft Rev 4, following "These technical justifications should include the following elements:" the current draft states as follow: "(1) An assessment of the excavated soil volume should be performed to identify its vibratory frequencies and mode shapes. These frequencies and mode shapes may be spurious in the SM solution, which can lead to unconservative or erroneous results. They can be identified as spikes in the transfer functions computed using SM, which do not appear in the corresponding transfer functions computed using DM." <u>Rationale for modification</u>: Trying to identify the vibratory frequencies and mode shapes of the excavated soil volume does not help to solve the issues of the SM's problem. The vibratory frequencies and mode shapes calculated from the excavated soil volume itself are not compatible with those of SASSI's calculations. The calculations of vibratory frequencies and mode shapes should include the soils deposits and the frequency dependent half-space but not just the excavated soil volume itself. The SM's issues are strictly inadequate modeling issues and should not be recommended.	ARES suggest to modify the paragraph as follow: (1) The DM only provides correct results in low frequency range dependent on the foundation size and the shear wave velocity of the supporting soil. An assessment of the excavated soil volume should be performed to identify its frequency dependent impedance functions and its response transfer functions at a few key nodes of interest. The impedance functions and transfer functions may be spurious in the SM solution, which can lead to	The intent of the recommendation is to provide guidance to address issues associated with SM/MSM to ensure that the solution will be consistent with the use of DM. SSI analyses based on DM, SM/MSM, or any other methods are reviewed by the staff on a case-by-case basis to determine their acceptability.

	unconservative or erroneous results. The valid low frequency limit of using DM can be found from the plots of transfer functions versus computed frequencies.	
4. Page 3.7.2-20, comment on the second element of the technical justifications (2), The current statement is not clear about the definition and the minimum requirement of using the option of MSM. Different versions of SASSI may have “different” user guide for using the option of MSM. The definition for MSM should be defined clearly. If the version of SASSI does not internally set those nodes located at free field as a default interaction nodes for the option of the MSM, then as a minimum, it should be required that the nodes on surface of the free field be modeled as interaction nodes.		Use of MSM is expected to improve the accuracy of the results. The proposed criteria are intended to provide guidance on implementation of MSM to address the underlying technical issues regardless of the particular software being used. Additional guidance on the use of MSM is provided in Item (3) in SRP Section 3.7.2 II.4, under the heading Specific Guidelines for SSI Analysis, to address the MSM.
5. Page 3.7.2-20, the third element of the technical justifications (3), it is not clear where the transfer functions in the system should be examined.	ARES suggests to add “….computed transfer functions at the key nodes of interest in the soil structural system”	The staff does not agree with the proposed resolution. To demonstrate the adequacy of an SSI analysis based on SM or MSM, the applicant is responsible for performing a comprehensive review of transfer functions throughout the soil-structure system. It is not the intent of the updated guidance to identify a subset of key locations that would facilitate this review since such key locations would be problem-dependent. The applicant is expected to select sufficient nodes and the staff reviews this on a case-by-case basis.

6. Page 3.7.2 -20, the fourth element of the technical justification (4), the frequency content of the ground motion input defined by the SSI analysis will practically always be affected by computed transfer functions. The key is to eliminate the spurious impedance and transfer function with the right modeling. An evaluation should always be on computed transfer functions and the associated computed output motions to ensure they are reasonable.		The staff agrees with the comment; and therefore, has revised SRP Section 3.7.2 II.4.C - Input Ground Motion, Specific Guidelines for SSI Analysis, as follows: "(4) An evaluation should be performed to ensure that the frequency content of the ground motion input important to the SSI analysis lies within a range that is minimally affected by the spurious vibration modes of the constrained excavated soil volume."
7. SRP 3.7.2.II.4 B. on page 3.7.2 – 15, half-space normally implies to the uniform half-space unless state layered half-space. The second sentence under B stating "For the half-space modeling of the soil media, the lumped parameter (soil spring) method and the compliance function methods are acceptable provided frequencies variations and layering effects are incorporated".	Since it involved the frequency variations and the layering effect, it is more appropriate to change the statement to: "For modeling of the support soil media, the lumped parameter (soil spring) method and the compliance function method are acceptable when frequencies variations and layering effects are incorporated".	The staff agrees with the comment; and therefore, has revised SRP Section 3.7.2 II.4.B as follows: "For modeling of the support soil media, the lumped parameter (soil spring) method and the compliance function methods are acceptable provided that frequency variations and layering effects are incorporated."
8. SRP 3.7.2II.C, page 3.7.2 – 16, iii, what is the technical basis or rationale for specifying 60%? 60% is a very significant reduction. *[NOTE: This is what is being referenced in the SRP:* *"When the guidance for SSI analysis presented above is not completely implemented, the spectral amplitude of the*		The rationale for the 60% limit on the use of the deconvolution analysis approach is to prevent the unrealistic reduction in the foundation level free-field response. This 60% limit corresponds to a reduction of 40%, not the 60% reduction indicated in the comment.

acceleration response spectra (horizontal component of motion) in the free field at the foundation depth shall be not less than 60 percent of the corresponding design response spectra at the finished grade in the free field. When the variation in soil properties are considered (as required by the "Specific Guidelines for SSI Analysis" below), the 60 percent limitation may be satisfied using an envelope of the three spectra corresponding to the three soil properties."]		
9. In the Technical issue 9, Standard Plant Site Parameters and Consideration for Seismic Design Basis, does concern about the potential effects of lateral soil variability in the design and analysis of nuclear power plant. If significant lateral soil variability is close to the NPP structures, the general assumption of horizontal layering with isotropic homogeneous soil properties in SSI analysis is no longer valid. The current Draft version does not provide any guideline on how to address the issue, particularly for using linear code such as SASSI.		The comment raises a question that is in need of development in the seismic engineering community in general. At this time, the approaches that might be developed by applicants/licensees to address significant lateral soil variability in SSI analysis are reviewed on a case by case basis.
10. In the Technical issue 9, Standard Plant Site Parameters and Consideration for Seismic Design Basis, the proposed enhancement improves the SRP guidance in the aspect of considering reasonable distribution of the site profile column frequencies over the amplified portion of the CSDRS. One important aspect within the same context of site amplification is the impedance ratio between the soil deposit and the underling bedrock. The impedance ratio has a significant effect in site response calculations. This technical issue should include a general guidance for the considerations of impedance ratios between the soils deposits and underlying bedrocks for development of generic site profiles to be used for standard design.		Technical Issue No. 9 is intended to address the concerns as discussed in MHI/MNES Comment 2. The impedance ratio between the soil deposit and the underlying bedrock is one of the many factors that an applicant needs to consider when developing a sufficiently broad set of postulated generic site profiles. There are many factors that affect site response analysis including impedance ration, potential inversion (i.e., presence of an intermediate layer that is less stiff than the layers immediately above and below it), and the depth to the underlying bedrock. The staff reviews this information on a case-by-case basis.

11. Page 3.7.2-22, Draft Revision 4, regarding to the technical issue No. 5 ground motion incoherency effect on seismic SSI, for structural loads, which are predominantly controlled by seismic input up to 10 HZ, the maximum acceptable reduction due to the effects of incoherent ground motion is 10 percent. What is the justification or technical basis of this reduction? If the design of a structural element saying, for example, the deep embedded structural wall according to the results of SSI analysis including the effect of the incoherency of the ground motion or take the advantages of the maximum of 30% reduction in response spectra whichever is governed, can one still take off the maximum of 10 percent of the structural loads in design of the embedded wall? It looks like a double bonus for the reduction.		The basis for the 10% limit on reductions for structural loads when using incoherence is that structural loads are dominated by low-frequency excitation and incoherency effects are negligible for low-frequency excitation. The staff's expectation is that any reasonable reduction in the structural loads due to incoherency effects would be small. For structural loads, if incoherency effects are considered in the SSI analysis, the maximum reduction from coherent results should be no more than 10%. This reduction cannot be automatically taken; it applies only where the incoherent results are more than 10% below the coherent results. Otherwise, the actual incoherent results are used in the structural assessment. If a decision is made to utilize incoherency, then their effect on both ISRS and structural loads must be used. However, when doing so, the incoherency analysis results are limited to a maximum reduction of ISRS (30%) and structural loads (10%), when compared to coherent results.
12. (a) For standard design of NPP, is it required to consider the effect of incoherency in the design process? Or should it be considered in the site specific evaluation stage when the ground motion incoherency is apparent at the specific plant site? (b) Another question regarding to the incoherency effects reduction: Is the incoherency effects applicable to vertical spectra also in addition to the horizontal spectra?		(a) This comment has been addressed in the NRC staff resolution to NEI Comment No. 23. (b) Yes, the incoherency effects are applicable to vertical spectra as well as horizontal spectra as described in ISG-01. The ISG states the following: "The staff accepts the use of the proposed horizontal and vertical CFs [coherency functions], as detailed in the Electric Power Research Institute (EPRI) report entitled, 'Hard-Rock Coherency Functions Based on the Pinyon Flat Array Data,'

		dated July 5, 2007 (ADAMS Accession No. ML071980104)."
13. Page 3.8.5-11, E. clean up the typo. Evaluation of………missing words or restructure the sentence.		The final SRP revision will was revised to address all editorial issues.
14. General comment on seismic uplift in SSI analysis, Technical issue No. 1 Many uplift foundation analytical models have been developed and implemented to different codes. Most models deal with the geometrical nonlinearity of the contacts between the structure and the ground under strong seismic motions. However, the capability of each model is different in treating the stiffness of soils (compliance functions), complex shape of the foundation, nonsymmetrical structure, coupling of three components of seismic ground motion, etc. Applications of different codes implemented in different codes could produce significant uncertainty in calculated results.	Although the adequacy of the mathematical model has been addressed in the guidance design and analysis procedures, it is very helpful to add guidance on how to deal with the uncertainty in calculated results arising from different analytical models or analysis techniques.	The staff recognizes that there are different analytical techniques to address the uplift effect on the seismic response analysis. However the industry practice for performing SSI analysis is to use linear methods. The acceptance criterion provided in SRP Section 3.7.2 ensures that the assumptions underlying the linear methodology remain valid. If uplift effect is found to be significant, an analysis is performed to assess the impact of uplift on seismic response/design. This analysis may be performed using the guidance provided in SRP Section 3.7.1 II.1.B Option 2 which ensures that uncertainties are captured in nonlinear methods for seismic analysis.
15. General comment on seismic stability evaluation for design of structure, Technical issue No. 2 Page 3.8.5-10, under the subsection 6, The mathematical model should adequately represent the dynamic characteristics of the structure and capture the vibration modes important for the sliding and overturning stability analysis. How about the mathematical model of the supporting soils? The soil model is equally important for this type of analysis. It is appropriate to add a brief requirement of the soil model here or refer to a pertinent section. In		The respective SRP criteria for the mathematical model are provided in Item vi (referred to as item 6 in the comment). Typically, the input motion is applied at the foundation of a structural model without the soil, using the input motion from the response of the linear SSI analysis. In this case there is no model of the supporting soil in the structural stability evaluation. To clarify this, the criteria in Item v was revised as follows: "If the input motion applied at the foundation of a structural model without the soil is developed from

subsection 7 and in many other places, it mentions minimum sliding, what is the definition of the minimum sliding? Is any tolerance limit for absolute value of calculated minimum sliding?		the response of the linear SSI analysis, justification is needed to demonstrate that any minimal sliding or uplift would not affect the assumed seismic input motion taken from the SSI analysis that does not consider any sliding and uplift. Alternatively, the structural model could be coupled with the soil model and a nonlinear SSI analysis performed." Guidance for modeling of the supporting soils to obtain the input motion for the separate structural model, or for performing a coupled structural and soil analysis is already given in SRP Section 3.7.2. Regarding the acceptable minimal sliding, criterion vii provides guidance to address issues associated with the impact of minimal sliding on adjacent structures, attached commodities, etc. This is reviewed by the staff on a case-by-case basis.
16. General comment on seismic soil pressure on embedded walls, Technical issue No. 4 Excellent technical basis and rationale for technical issue No. 4 were given in the report entitled "Technical Rationale for Proposed Enhancement to Seismic and Structural Review Guidance", J. Xu et al. February 2013. The acceptance criteria on the 4, Design and Analysis Procedure (page 3.8.4-11), Subsection H states that consideration of dynamic lateral soil pressure on embedded walls is acceptable if the lateral earth pressure loads are evaluated for the governing of the three cases mentioned in the guidance. Due to the inertia and wave propagation effects, the proposed second method (embedded SSI/FEM analysis model) might likely produce larger earth pressures then those of other two classical methods, particularly in the	A guideline for determination of the reasonable fraction of the passive earth pressure will be very helpful.	This issue has been addressed in the NRC staff resolution to MHI/MNES Comment No. 4.

upper portion of the embedded wall. It is logical to use the enveloped results of the three methods in lieu of the governing case. Subsection H states that “For case (3) the analysis should include, as a minimum, the fraction of the passive earth pressure assumed in the stability calculations performed in accordance with SRP Section 3.8.5.”		
17. General question regarding to the specification for minimum power spectral density requirement for non RG 1.60 horizontal spectrum, SRP 3.7.1-10: If the design time history is developed from the required matching CSDRS which has been modified from the RG 1.60 spectra to include some more EUS high frequency content, the target PSD functions provided in the Appendix A is no longer valid and a compatible target PSD should be generated based on the guideline and procedures provided in the Appendix B. For the case of the spectra is non-consistent with the Magnitude and Distance bin shape in NUREG/CR-6728 (such as the one described above that consists of major portion of RG 1.6), is any additional guideline for generate the target PSD?		This comment has been addressed in the NRC staff resolution to NEI Comment No. 7.
GEH Comments:		
1. SRP 3.7.2, Section II, Acceptance Criteria, SRP Acceptance Criteria, Item 4: Soil Structure Interaction (Item B on page 3.7.2-15)	Expand the discussion of the finite element discretization of the excavated soil volume to include: “The finite element mesh of the	The staff agrees with the observation; however, the respective guidance in the SRP is appropriate for determining the frequency transmitting capability of the finite element mesh size. The related SRP guidance is quoted below: “In the SSI analysis of embedded structures using

	excavated soil/rock volume may be sized to pass 50 Hz or the highest frequency of significance in all directions for the Upper Bound soil/rock profile. The same mesh may be used for the Lower Bound and Best Estimate profiles for which the passing frequencies are lower."	the substructure approach, the finite element discretization of the excavated soil volume should have a mesh size in both the horizontal and vertical directions that is appropriate for adequately transmitting seismic motions over the frequency range of interest. The geometric regularity of the mesh (aspect ratio and size) is also an important characteristic of the mesh to ensure the adequacy of the computational capability." The guidance is intended for general applications including site-specific and generic designs. In generic designs, the site profiles do not correspond to upper bound, best estimate, and lower bound.
2. SRP 3.7.2, Section II, Acceptance Criteria, SRP Acceptance Criteria, Item 4: Soil Structure Interaction (Item (2) on page 3.7.2-20)	Clarify that the modified subtraction method (MSM) is also known as the extended subtraction method (ESM).	The SRP uses the MSM designation which is the generally recognized terminology.
M. Tabatabaie Comments:		
1. Third paragraph, Section 3.1.B discusses mesh size requirement for excavated soil model in SASSI. Although it is a correct statement for the embedded structures, it does not address the situation for the surface-supported structures and/or portions of the embedded structure(s) that have surface-supported portions where there is no associated excavated soil model. In these situations, the interaction nodes at the base of the surface supported structure(s) must also meet mesh size requirement for both the horizontal and vertical directions.		The staff agrees with the comment; and therefore, will revise SRP Section 3.7.2 II.4. B - Modeling of Supporting Soil, as follows: "In the SSI analysis of surface-supported structures using the substructure approach, or portions of embedded structures that are surface-supported, where there is no associated excavated soil volume, the guidance in the preceding paragraph is applicable to the mesh at the base of the surface supported structures."

2. It seems to be a common perception that for the SSI analysis using vertical input, the mesh size requirement only needs to be satisfied for the vertical element sizes. Although this may, in general, be true for the complete SSI analysis (or the so-called one-step method), it is not true for the substructure method used in SASSI. In other words, both the horizontal and vertical mesh size for the excavated soil model (or horizontal mesh size for the interaction node mesh of surface-supported structure) must satisfy the wave length requirement regardless of whether the model is being analyzed for the horizontal or vertical excitation. This has to do with how the point load solution is obtained. Reinforcing of this fact will also be helpful as a guide in the SRP.		The staff agrees with the comment, and therefore, has revised paragraph as follows: "In the SSI analysis of embedded structures using the substructure approach, the finite element discretization of the excavated soil volume should have a mesh size in both the horizontal and vertical directions that is appropriate for adequately transmitting seismic motions over the frequency range of interest. Both the horizontal and vertical mesh size for the excavated soil model should satisfy the wave length requirement regardless of whether the model is being analyzed for the horizontal or vertical excitation. The geometric regularity of the mesh (aspect ratio and size) is also an important characteristic of the mesh to ensure the adequacy of the computational capability."
3. In general, SM does not appear to provide acceptable transfer functions for typical nuclear structures. In writer's opinion, its use should be discouraged. The MSM can provide significantly improved results for a small increase in numerical effort. Including additional layers of interaction nodes above and beyond those of MSM provides only incremental improvement of the computed transfer functions.		The staff agrees with the observation; however, the proposed criteria (Items (1) through (4) in SRP Section 3.7.2 II.4, under the heading Specific Guidelines for SSI Analysis, provides the process for appropriate implementation of SM/MSM.