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**New Plant Seismic Issues  
Resolution Program – S2.1  
Incoherence Project – SASSI-  
CLASSI Comparisons**

May 31, 2007

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## Topics for Discussion

- Background
- SASSI-CLASSI Comparisons for Incoherent Seismic Response
- Effect of Rock Coherency Function
- NRC Comments

## Background

- Past NRC Interaction
- Representative NPP model for SSI analyses
- CLASSI-SASSI Methodologies

## Past NRC Interaction on Seismic Wave Incoherence

- EPRI Report 1013504
- Dec. 20-21, 2006 NRC Meeting @ EPRI
  - CLASSlinco was validated for use in analysis of incoherent ground motion by comparison to analytical solutions from published literature
    - Luco & Mita, 1987; Veletsos & Prasad, 1989; Luco & Wong, 1986
- March 1, 2007 NRC Meeting
  - SASSI results for rigid massless foundations agreed closely with CLASSlinco and analytical solutions from published literature (Luco & Mita, 1987)
  - Preliminary SASSI and CLASSI comparisons presented for representative NPP stick model with SSI

## Conclusions from March 2007 NRC Meeting

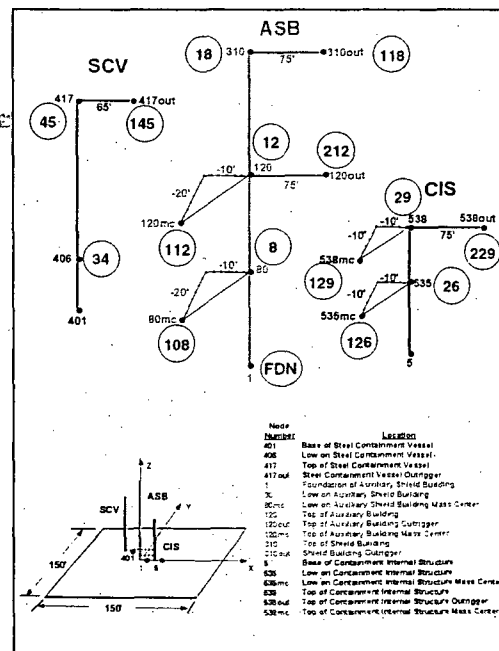
- Response spectra and transfer functions for CLASSlinco, SASSI-SRSS, & SASSI-LC were presented
- Very close agreement for coherent ground motion as would be expected.
- All methods agreed closely for incoherent response spectra & transfer function amplitudes at the foundation
- There was generally good agreement at structure locations, but there are some exceptions requiring more investigation
- Overall, good agreement between CLASSlinco and either SASSI method was demonstrated
- Recommended action - Examine outrigger response not in agreement

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## Representative NPP Structure Stick Model with Outriggers and Offset Mass Centers

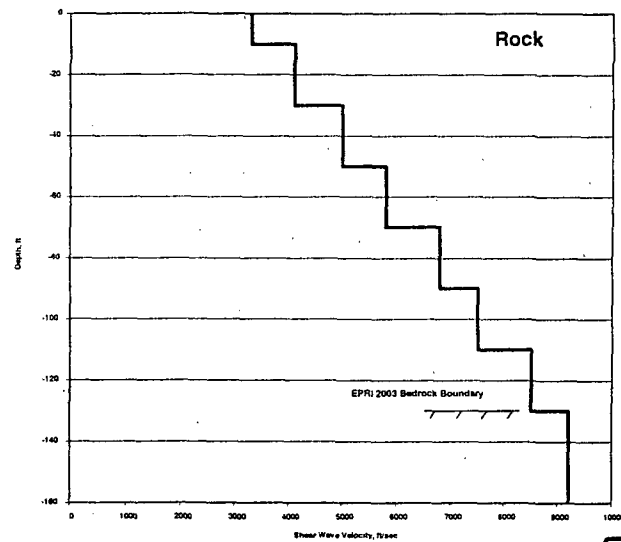


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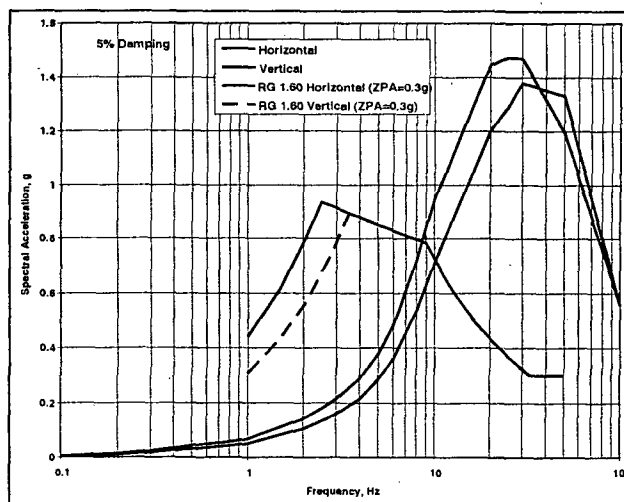
## Rock Site Profile Shear Wave Velocities vs. Depth



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## Site-Specific Response Spectra for Rock Site at Ground Surface (Depth 0-ft)



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## CLASSI-SASSI Methodologies

- CLASSlinco
  - Deterministic phasing
- CLASSlinco-SRSS
  - Structure response to each foundation input motion combined by SRSS
- SASSI-Simulation
  - Spatial modes assigned random phasing
  - Mean of structural response to spatial modes computed
- SASSI-SRSS
  - Structural responses to each spatial mode are combined by SRSS
- SASSI-LC
  - Linear combination (algebraic sum) of spatial modes used to compute structural response

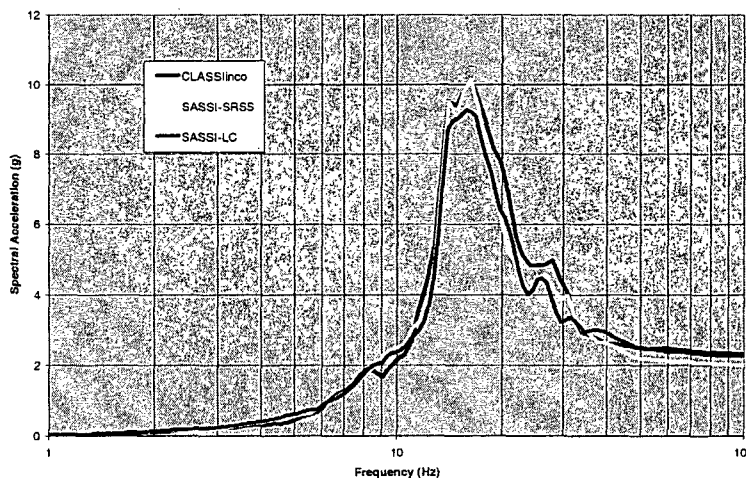
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## CLASSI-SASSI Agreement is Generally Good e.g., SCV Outrigger (Node 145) Z response due to Z input (March meeting)

Node 145-SCV z response due to z input



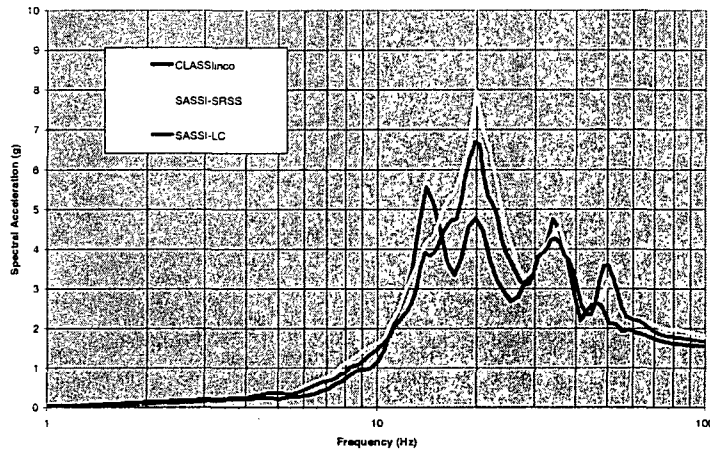
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## CLASSI-SASSI Agreement Not Adequate for CIS Outrigger (Node 229) Z response due to Z input (March meeting)

Node 229-CIS z response due to z input



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## CLASSI-SASSI Validation for Incoherent Ground Motion

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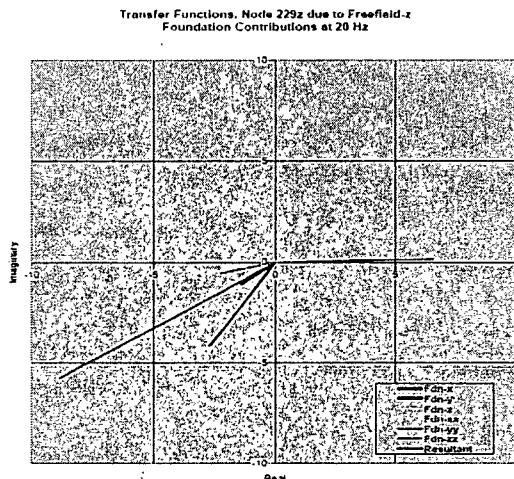
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## Examination of the Differences

- Characteristics of foundation/structure/solution techniques that lead to differences have been identified
- Good agreement between CLASSI and SASSI for foundation transfer function amplitude and response spectra for all six DOF
- The relative phasing of foundation response components is different between CLASSI and SASSI solutions such that the structural response is different
- Reevaluated the treatment of phasing in both CLASSI and SASSI to capture the random incoherence nature

## CIS Outrigger (Node 229) Transfer Function @ 20 Hz

- Structure transfer function (CLASSI) is composed of many foundation components of varying amplitude and phase
- The resultant transfer function @ 20 Hz includes significant addition and subtraction of 5 foundation components and the 6<sup>th</sup> component has a 10% effect



## CLASSI-SASSI Methodologies

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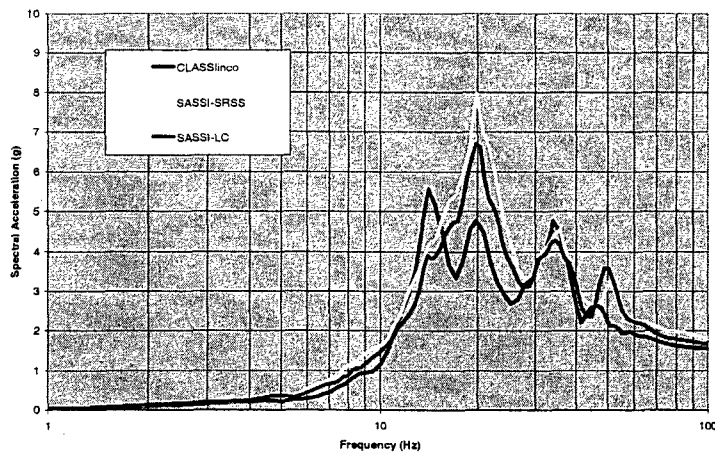
## Findings

- Appropriate use of CLASSI
  - CLASSlinco for scoping and preliminary evaluation
  - CLASSlinco-SRSS for final evaluation
- Appropriate use of SASSI
  - SASSI-LC for scoping and preliminary evaluation
  - SASSI-Simulation or SASSI-SRSS for final evaluation



## CLASSI-SASSI Agreement Not Adequate for CIS Outrigger (Node 229) Z response due to Z input (March meeting)

Node 229-CIS z response due to z input



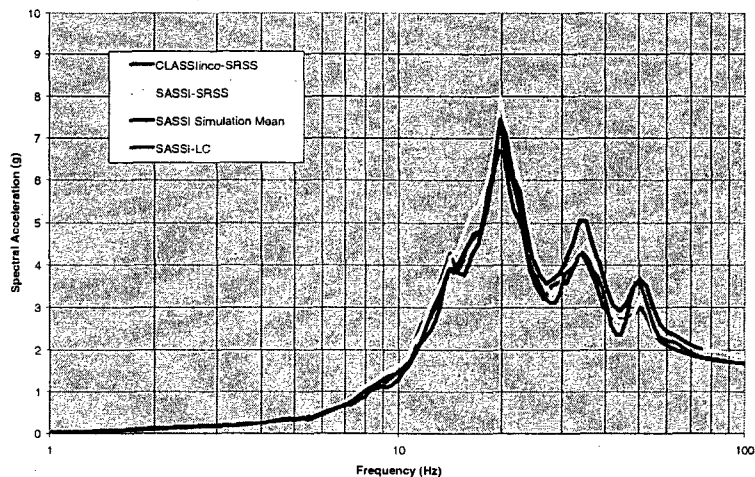
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## CIS Outrigger Response Comparison

Node 229-CIS z response due to z input



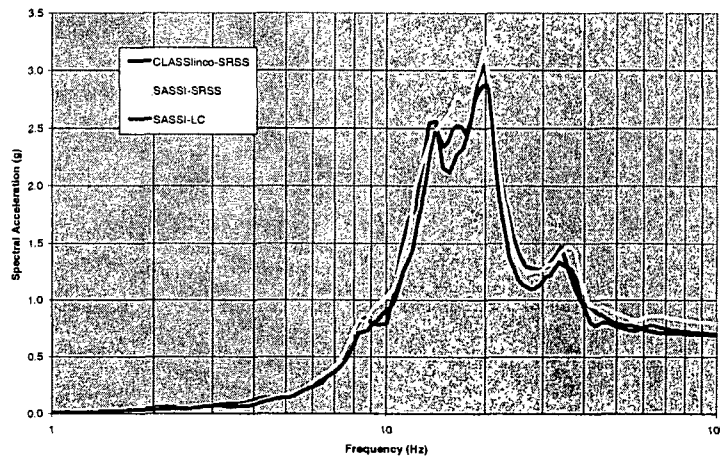
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## CIS Mass Center Response Comparison

Node 29-CIS x response due to z input



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## Conclusions

- CLASSI and SASSI incoherency approaches that incorporate random phasing are in close agreement for all cases considered to date
- CLASSlinco-SRSS, SASSI-Simulation, and SASSI-SRSS are validated for evaluation of seismic response to incoherent ground motion
- CLASSlinco and SASSI-LC are good approximations

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## Next Steps

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- Industry Actions
  - Document CLASSI-SASSI comparisons
  - Develop user guide for running incoherent SSI analysis
- NRC Action
  - Reach closure
  - Concurrence that CLASSI and SASSI can be used to evaluate seismic response to incoherent ground motion

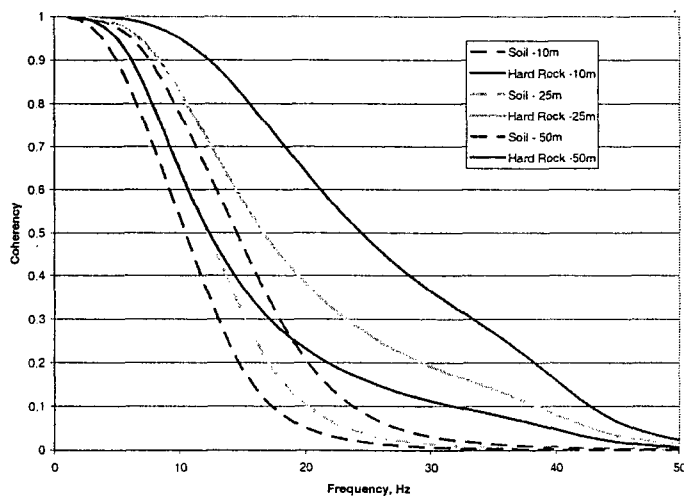
## Effect of Rock Coherency Function

## Abrahamson Coherency Functions

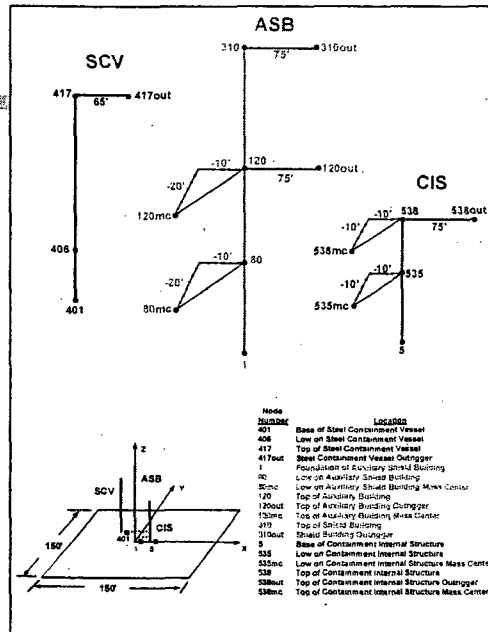
- Ground motion coherency functions
  - Soil – Surface foundations (NAA 2005-2006)
  - Soil – Embedded foundations (NAA Dec 2006)
  - Rock – Surface and embedded foundations (NAA April 2007)
- Effect of NAA 2007 rock ground motion coherency functions
  - CLASSInco seismic analyses performed
  - Rock site profile & high frequency input motion
  - Three free-field components applied simultaneously
  - Comparison of structure response due to coherent motion, incoherent motion (soil), and incoherent motion (rock)

## Comparison of Rock and Soil Coherency Functions

Comparison of Horizontal Coherency Functions



# **Representative NPP Structure Structure Stick Model with Outriggers and Offset Mass Centers**

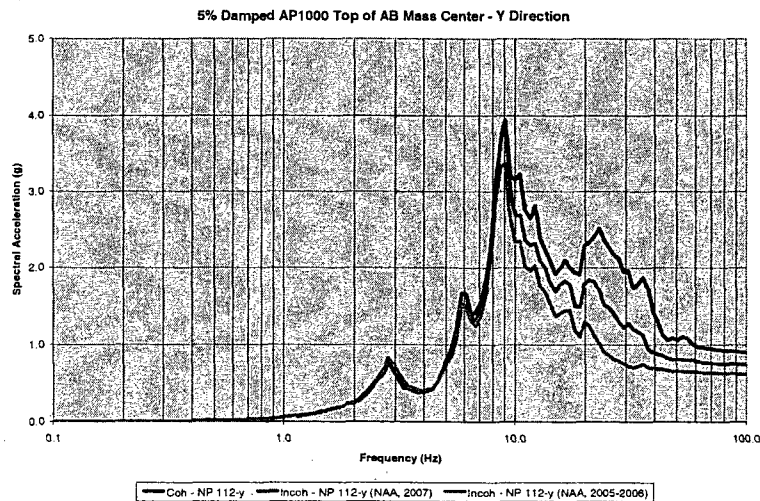


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## **Comparison of In-Structure Response Spectra Horiz. Y – Top of Auxiliary Building Node 120mc**

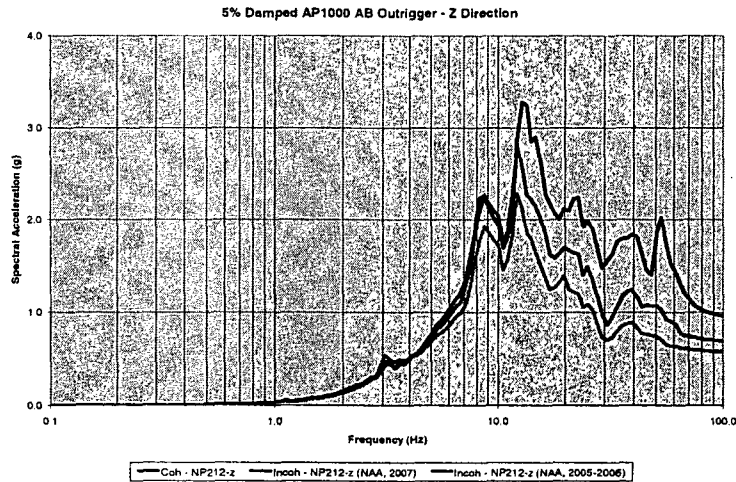


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## Comparison of In-Structure Response Spectra Vert. Z – Outrigger Top of Auxiliary Building Node 120out

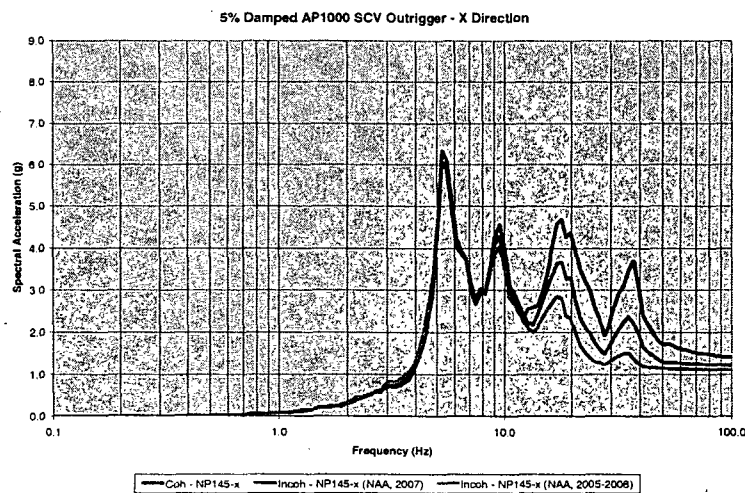


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## Comparison of In-Structure Response Spectra Horiz. X – Outrigger Top of Steel Containment Vessel Node 417out



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