SCREENING CRITERIA FOR STRUCTURES AND SITES SENSITIVE TO SEISMIC INTERACTION EFFECTS

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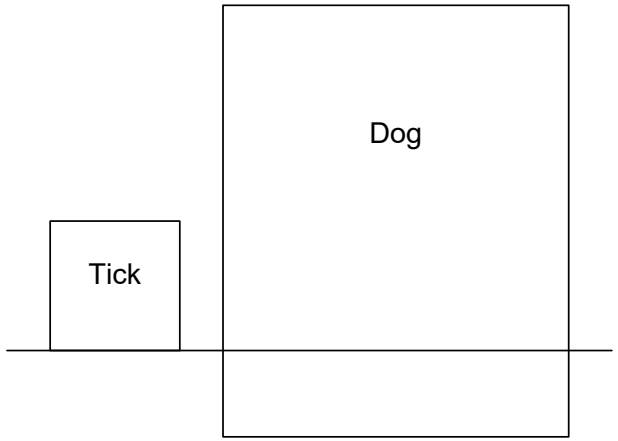
OVERVIEW

- Structure-Soil-Structure Interaction (SSSI) - effect of a neighboring structure on the dynamic response of a target structure on a common soil site
  - Previous studies of this effect yield varied results
- Sensitivity of SSSI effects on seismic response of a target structure is assessed with multiple variable parameters:
  - Structural response of the target and neighbor varied to create Low Frequency (LF) and High Frequency (HF) model
  - Two site/motion are considered:
    - CEUS motion with a medium/hard rock profile
    - WUS motion with a soft soil profile
  - Distance of structures is varied from 10' separation to 1000' separation.
- Acceleration Response Spectra at the same location in each model are compared

PREVIOUS STUDIES

- 2010 5th International Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics – Structure-to-Soil-Structure Interaction Analysis: A Case Study – Anderson and Elkhoraibi
  - Hanford Waste Treatment Plant (WTP) Pretreatment Facility Complex
    - Small high frequency structure (target) located near much larger lower frequency structure
    - Medium soil profile; WUS input motion
    - Target structure exhibited higher response as neighboring structure shifted response into peak of input motion
- DOE NPH Meeting 2011 - Structure Soil Structure Interaction Effects: Seismic Analysis of Safety Related Collocated Structures – Carey et al.
  - Savannah River Site (SRS)
    - Similar structural characteristics between neighboring buildings, some embedded
    - Soft to medium soil profile; CEUS input motion
    - SSSI lowers seismic response of the target structure
- These 2 studies prove the "dog and tick" theory
  - Tick goes along for the ride on the dog
  - Dog walks the same even after the tick gets full



PREVIOUS STUDIES

- SMiRT 21 – Sensitivity of Separation Distance on the Structure-Soil-Structure Interaction Response of a Realistic Model – Anderson et al.
  - Uses WTP model/soil/motion with varying separation distances
    - Vertical and parallel direction not much affect
    - For perpendicular direction, still had some affect at 100' specifically at frequencies less than the target structure response ; no effect at 1000'
- SMiRT 22 – Effect of Separation Distance and Soil Parameters on the Structure-Soil-Structure Interaction Response of Adjacent Deeply Embedded Structures – Anderson et al.
  - Two identical deeply-embedded structures
    - Embedded structural responses are high frequency
    - Both soft soil with WUS and rock with CEUS are considered
    - Effect is much more pronounced for the soft soil case and mostly negligible for the rock case
- These studies may support that the soil/motion and distance has more of an impact that the structural characteristics, i.e. not dog and tick

ANALYSIS PLAN

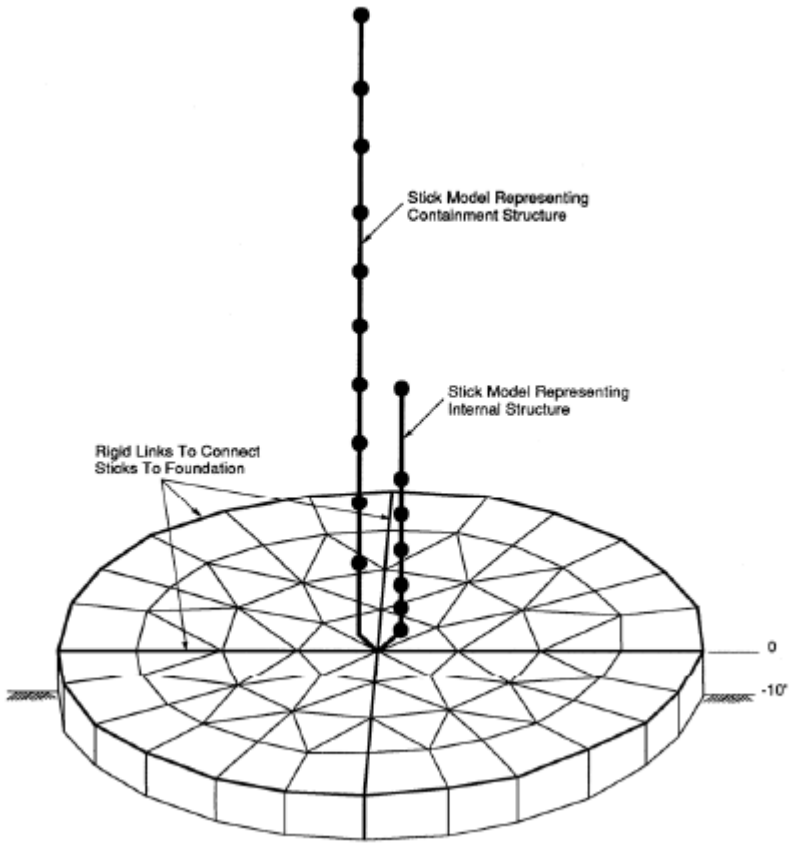
- Two structure-types
  - LF and HF
- Two motion/soil combinations
  - WUS and CEUS
- Single structure used as a base case
- Three distances considered
  - 10’, 100’, 1000’
  - Separation is in the X-direction axis
- 28 cases as permutations of the above parameters
- X, Y, and Z results compared

ANALYSIS CASES UTILIZED

- For the parameters used, a significant difference was not apparent after 10' separation
  - Only 10' and individual analyses are compared
- In past studies the most sensitive direction is on the axes of separation
  - Only x-direction results are compared
- Final Cases (Target_Neighbor_Soil/Motion):
  - HF_HF_CEUS; LF_LF_CEUS
  - HF_HF_WUS; LF_LF_WUS
  - HF_LF_WUS; HF_LF_CEUS
  - LF_HF_WUS; LF_HF_WUS

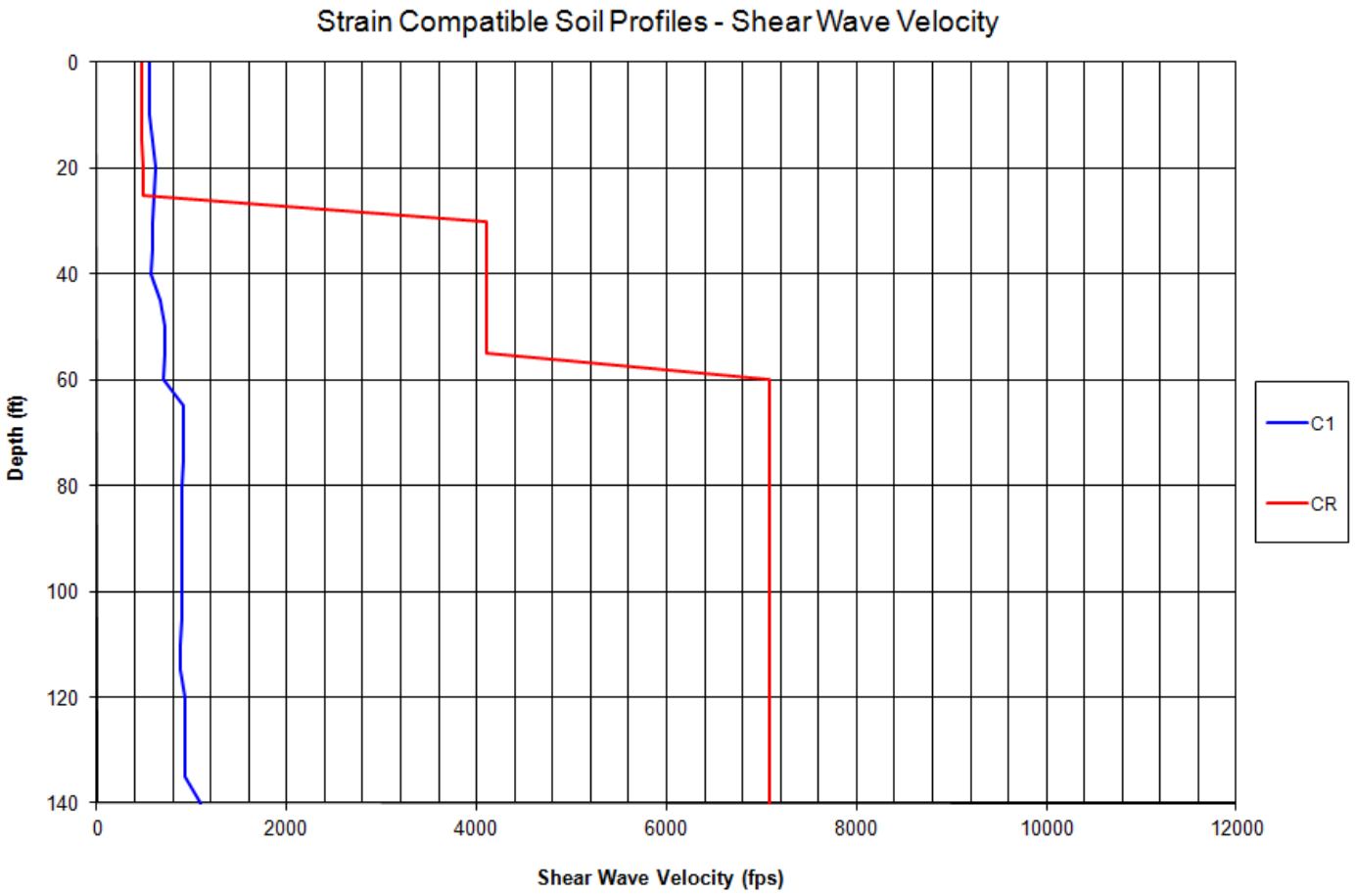
STRUCTURAL MODEL

- SASSI Example Problem 1
  - Frequency ~5Hz (LF)
  - A "high frequency" version is created by decreasing mass ~16Hz (HF)
  - Results are compared at the top of the containment structure



SITE CHARACTERISTICS

- C1: Soft soil
  - Paired with a typical WUS motion (~1 to 10Hz peak)
- CR: Rock
  - Paired with a site specific CEUS motion (~20 to 30 Hz peak)
- Only 140' depth shown here



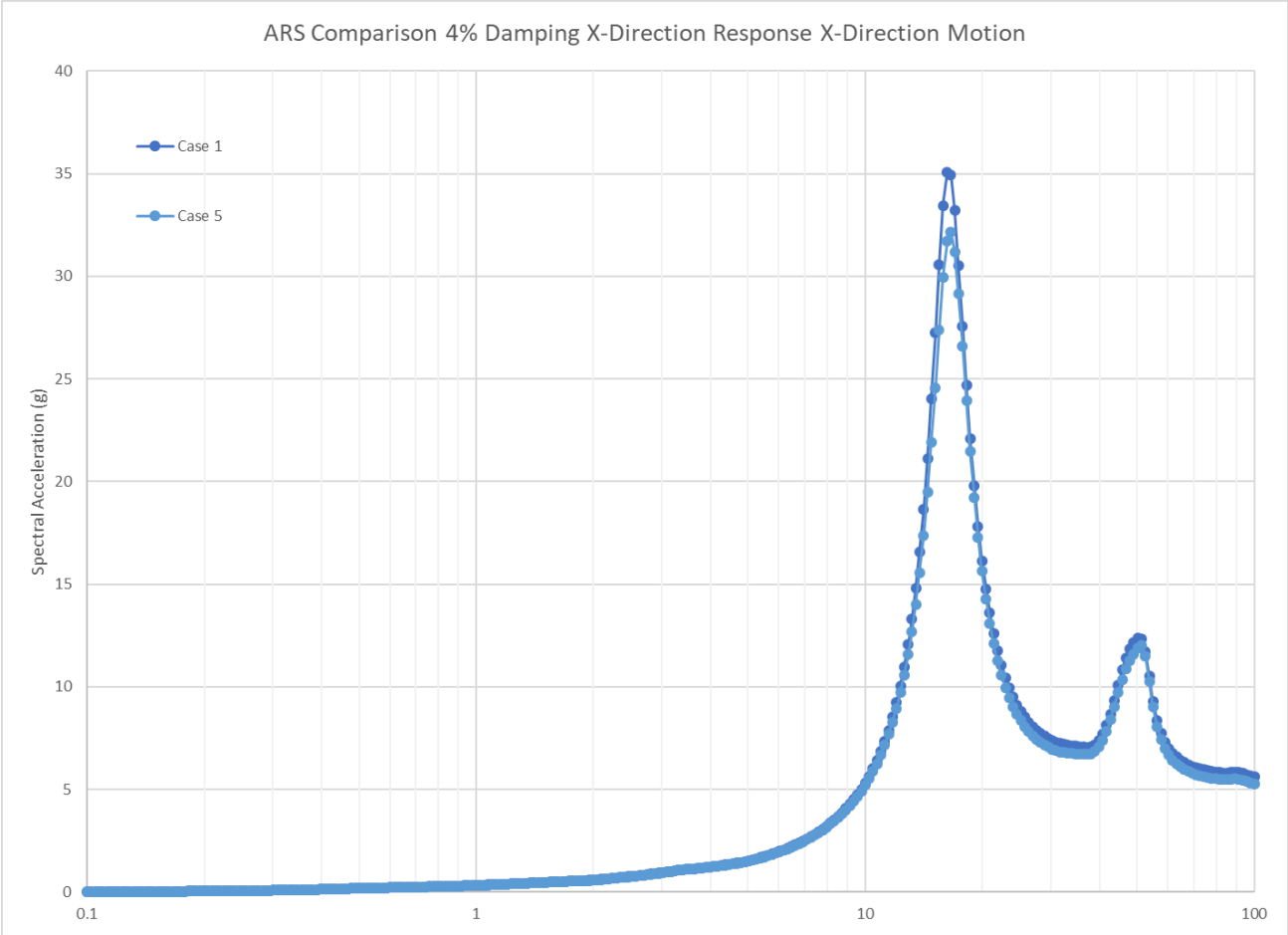
ANALYSIS/RESULTS

- Analysis completed using SASSI2010
  - Random Vibration Theory
- ARS reported at top of containment in target structure only
  - 4% damping
  - No co-directional effects; x-response due to x-motion

CEUS HF INDIVIDUAL (C1) VS. 10' HF NEIGHBOR (C5)

Both structures should resonate with motion/soil

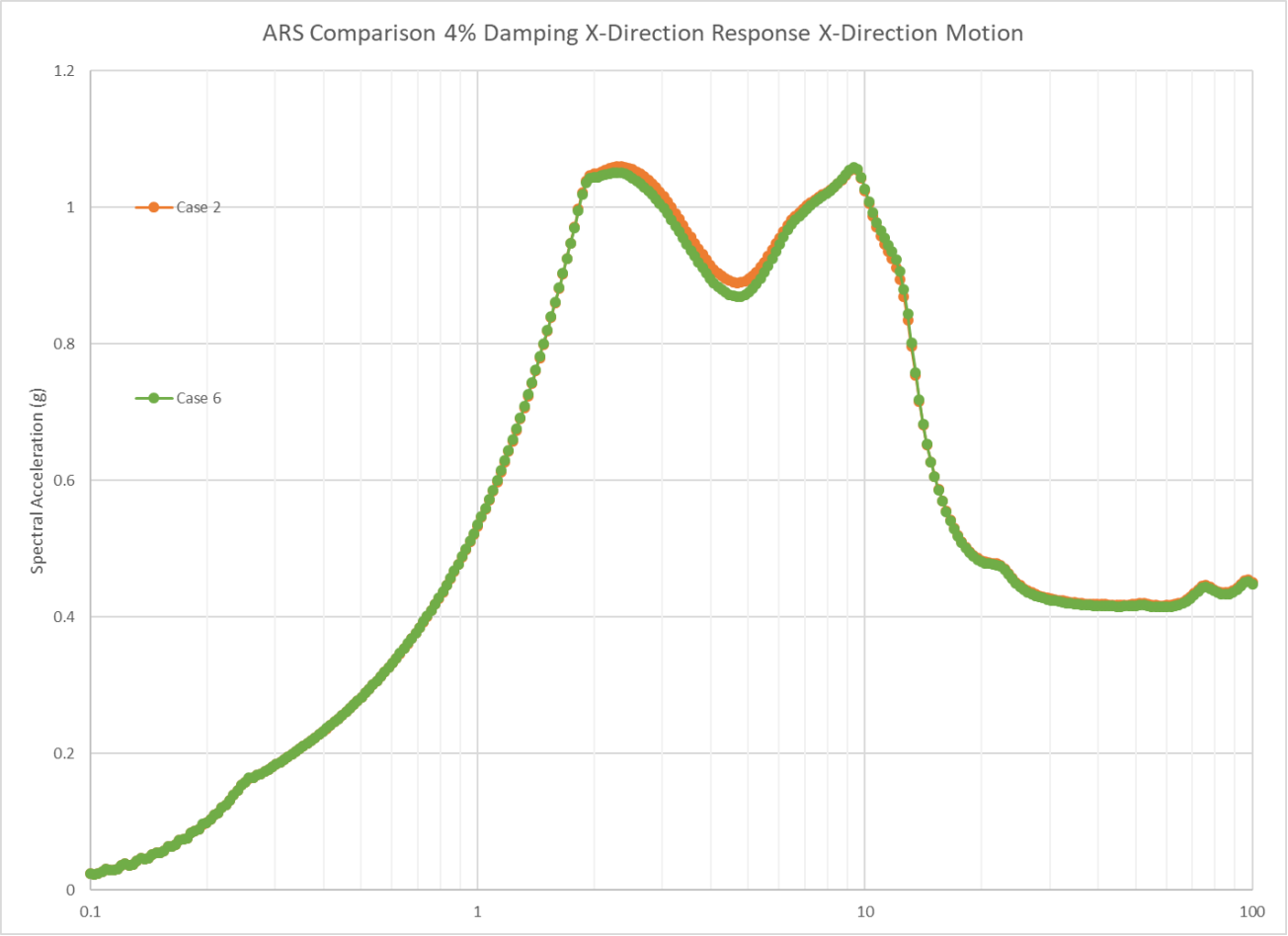
Presence of the identical neighboring structure lowers the first mode response and increases the second mode response



WUS HF INDIVIDUAL (C2) VS. 10' HF NEIGHBOR (C6)

Both structures respond beyond the peak of the motion/soil

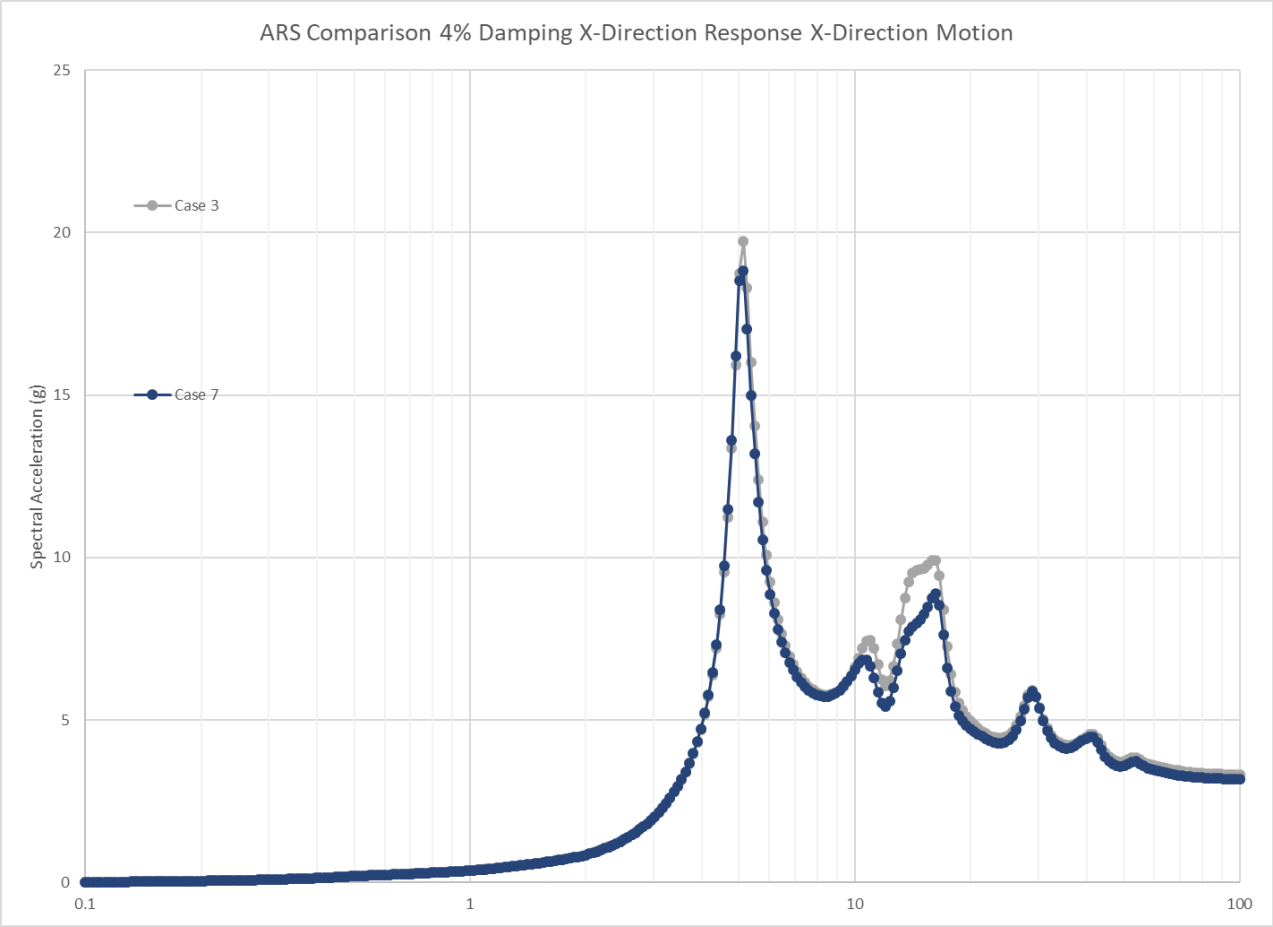
Presence of the identical neighboring structure lowers the response



CEUS LF INDIVIDUAL (C3) VS. 10' LF NEIGHBOR (C7)

Both structures response prior to the peak of the motion/soil

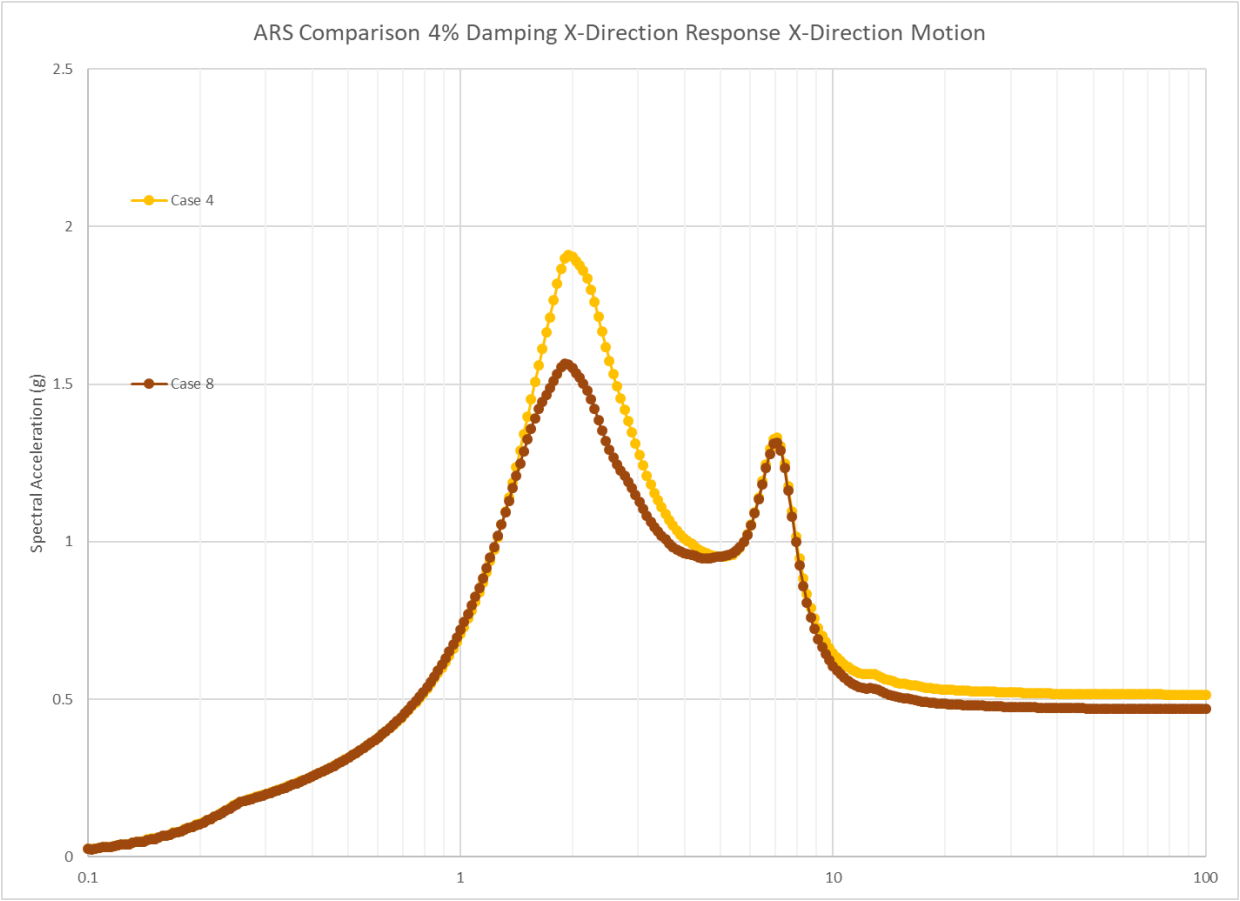
Presence of the identical neighboring structure lowers the first and second mode responses



WUS LF INDIVIDUAL (C4) VS. 10' LF NEIGHBOR (C8)

Both structures should resonate with motion/soil

Presence of the identical neighboring structure lowers the first mode response

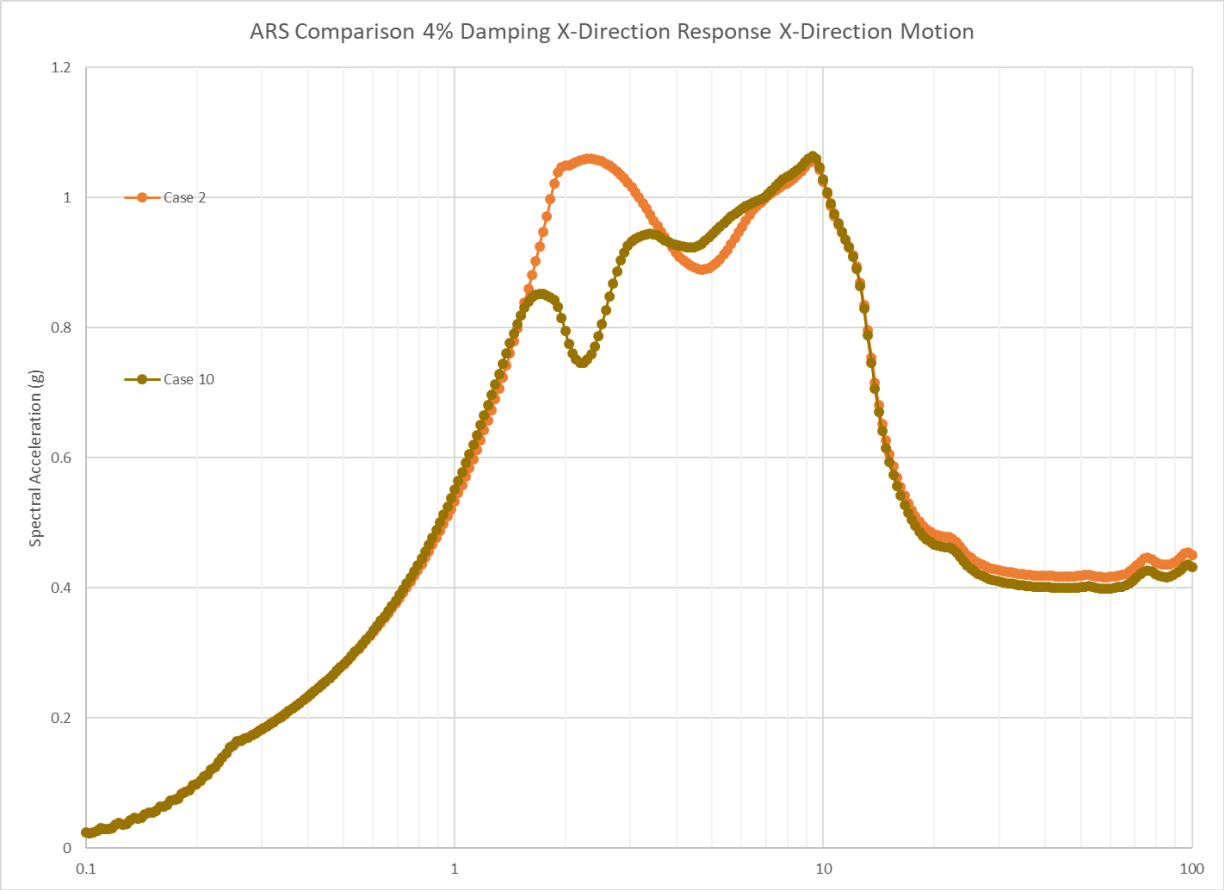


WUS HF INDIVIDUAL (C2) VS. 10' LF NEIGHBOR (C10)

Both responses are reported from the HF target structure

Neighboring structure should resonate with motion/soil

Presence of neighboring structure increases the response near the peak of the neighbor (5 Hz) but a decreased response is observed elsewhere

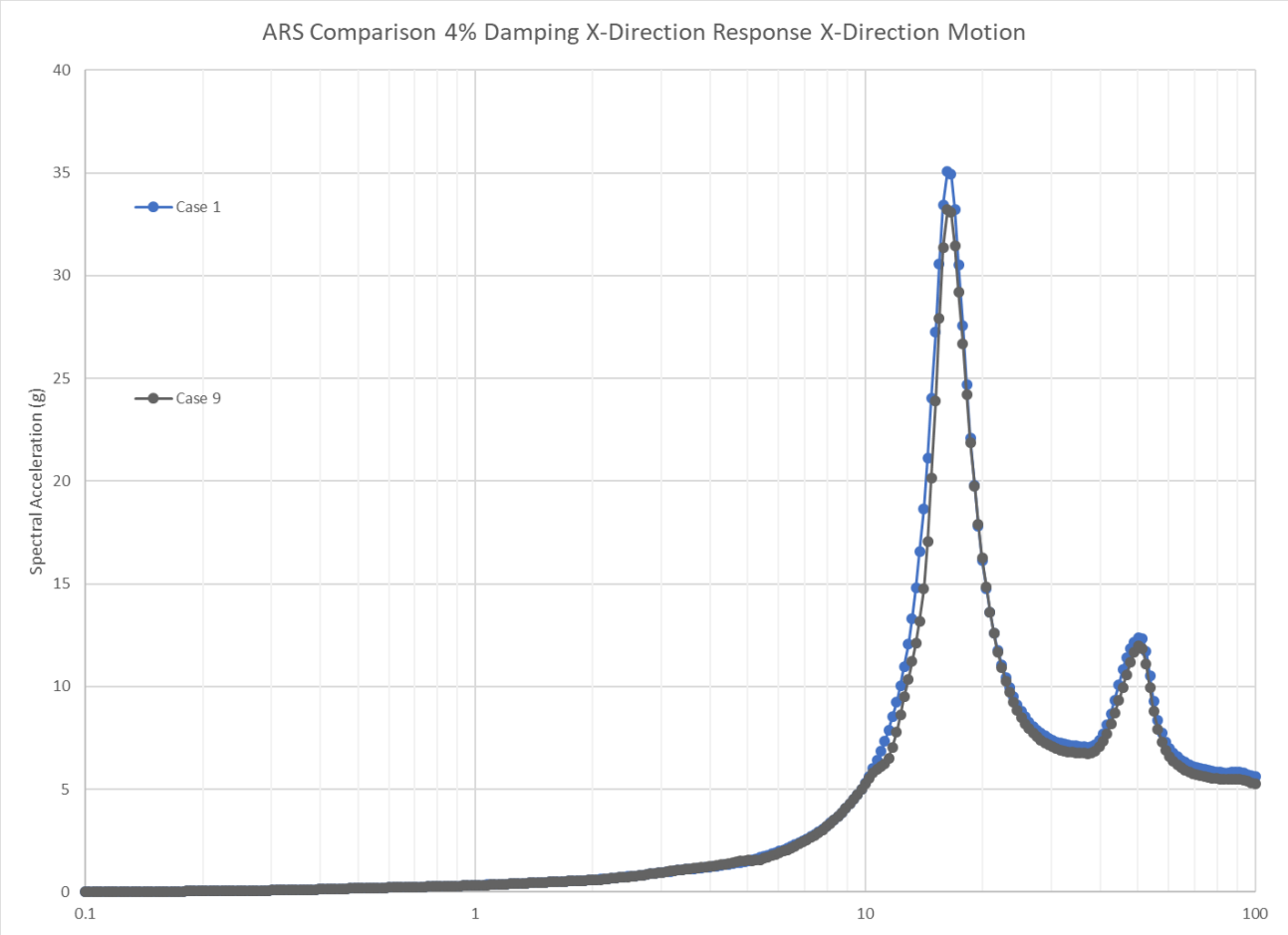


CEUS HF INDIVIDUAL (C1) VS. 10' LF NEIGHBOR (C9)

Both responses are reported from the HF target structure

Target structure should resonate with motion/soil

Presence of neighboring structure decreases first mode response slightly; similar to HF neighbor

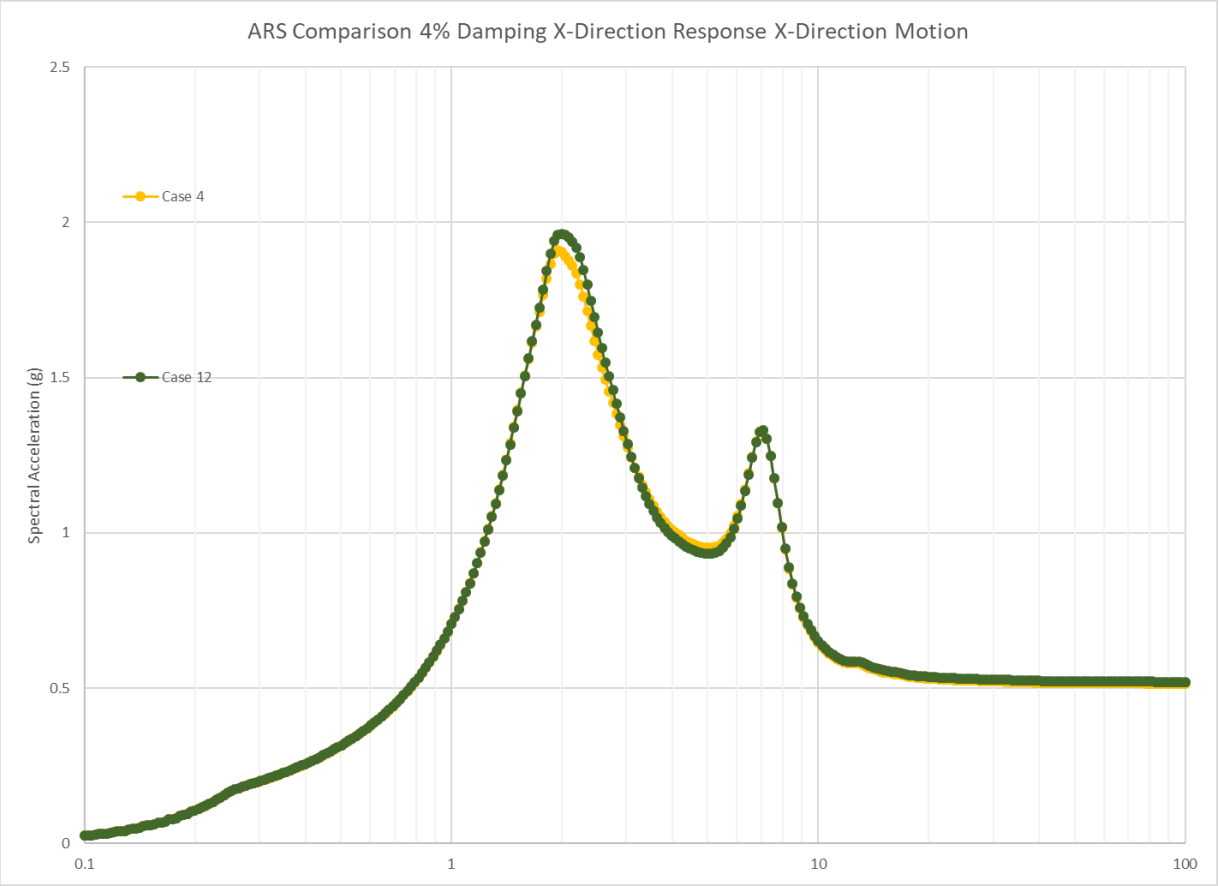


WUS LF INDIVIDUAL (C4) VS. 10' HF NEIGHBOR (C12)

Both responses are reported from the LF target structure

Target structures should resonate with motion/soil

Presence of neighboring structure increases the response of the first mode

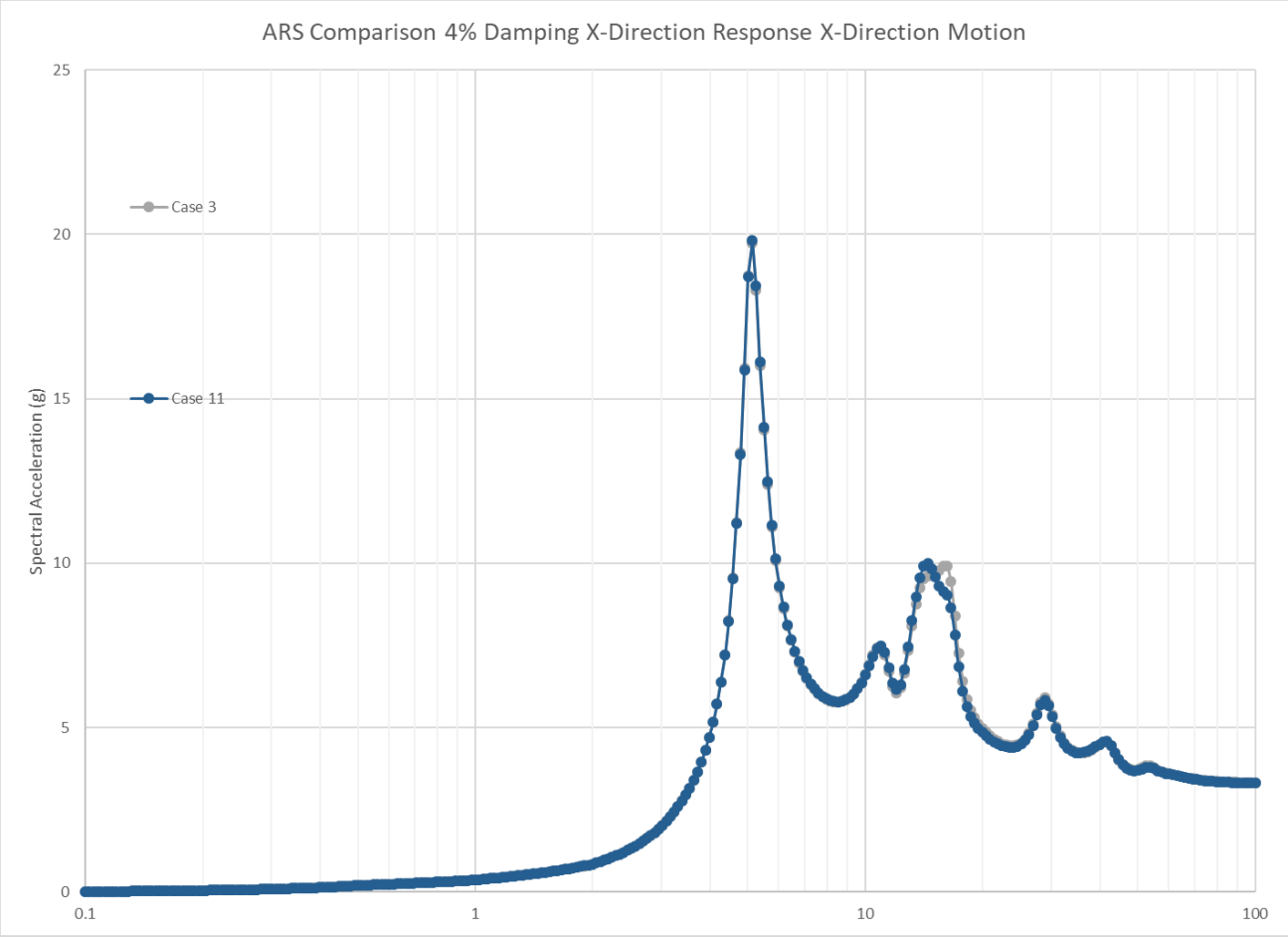


CEUS LF INDIVIDUAL (C4) VS. 10' HF NEIGHBOR (C12)

Both responses are reported from the LF target structure

Neighboring structure should resonate with motion/soil

Presence of neighboring structure changes the response near the neighboring structure frequency



OBSERVATIONS

- Identical or very similar structures, regardless of soil
  - SSSI effect lowers response of target structure
  - Similar to SRS findings
- Neighboring structure of different frequency characteristics
  - Difference observed at neighboring structure's dominant frequency

CONCLUSIONS

- Mismatch of structural response characteristics can be a significant factor
  - Specifically observed to cause change in response of target structure near the dominant frequency of the neighboring structure
- Missing factors to draw other conclusions:
  - Footprint size
  - Depth of embedment
  - Effects on secondary modes for structures with dual systems

QUESTIONS?