Shear Wave Velocity in Engineered Backfill Material Under Category I Structures

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Agenda

- Objectives
- Background
- When Shear Wave Velocity (SWV) Measurement Is/Is Not Appropriate
- Field Confirmation Challenges
- Generic ITAAC for SWV
- Conclusions and Wrap-up

Objectives

- Reach agreement with NRC on when confirmatory SWV measurement is appropriate
- Reach agreement with NRC on language for confirmatory SWV ITAAC

Background

- Standard Review Plan (NUREG-0800) describes *competent material* as in-situ material having a minimum SWV of 1,000 fps (Section 3.7.2)

  Background of "competent" material (qualitative assessment)
  - 1,000 fps a "surrogate" for competent material
  - > 1,000 fps confidence in subsurface
  - < 1,000 fps may require additional studies, however does not mean site is unacceptable

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Background

- Each of the five DCDs list SWV as a Tier 1 site parameter
- For the Vogtle ESP, NRC required an ITAAC for SWV of engineered backfill under Category I structures
- It is our understanding that NRC staff considers SWV to be an important DCD Tier 1 site parameter
- COLAs include a generic ITAAC on compaction requirements for backfill under Category I structures

Background

- Typically, backfill testing includes grain size, percent compaction (density), moisture content, and Atterberg limits (if appropriate). Additional QC inspections include lift thickness, number of compactor passes, amount of compactor overlap, and compactor frequency
- Where a site specific design requires significant backfill under Category I structures, individual COL applicants or COL holders may choose to construct a test fill to assist in the design of the production fill, but this is not a requirement

Cases Considered

Category I structures founded:

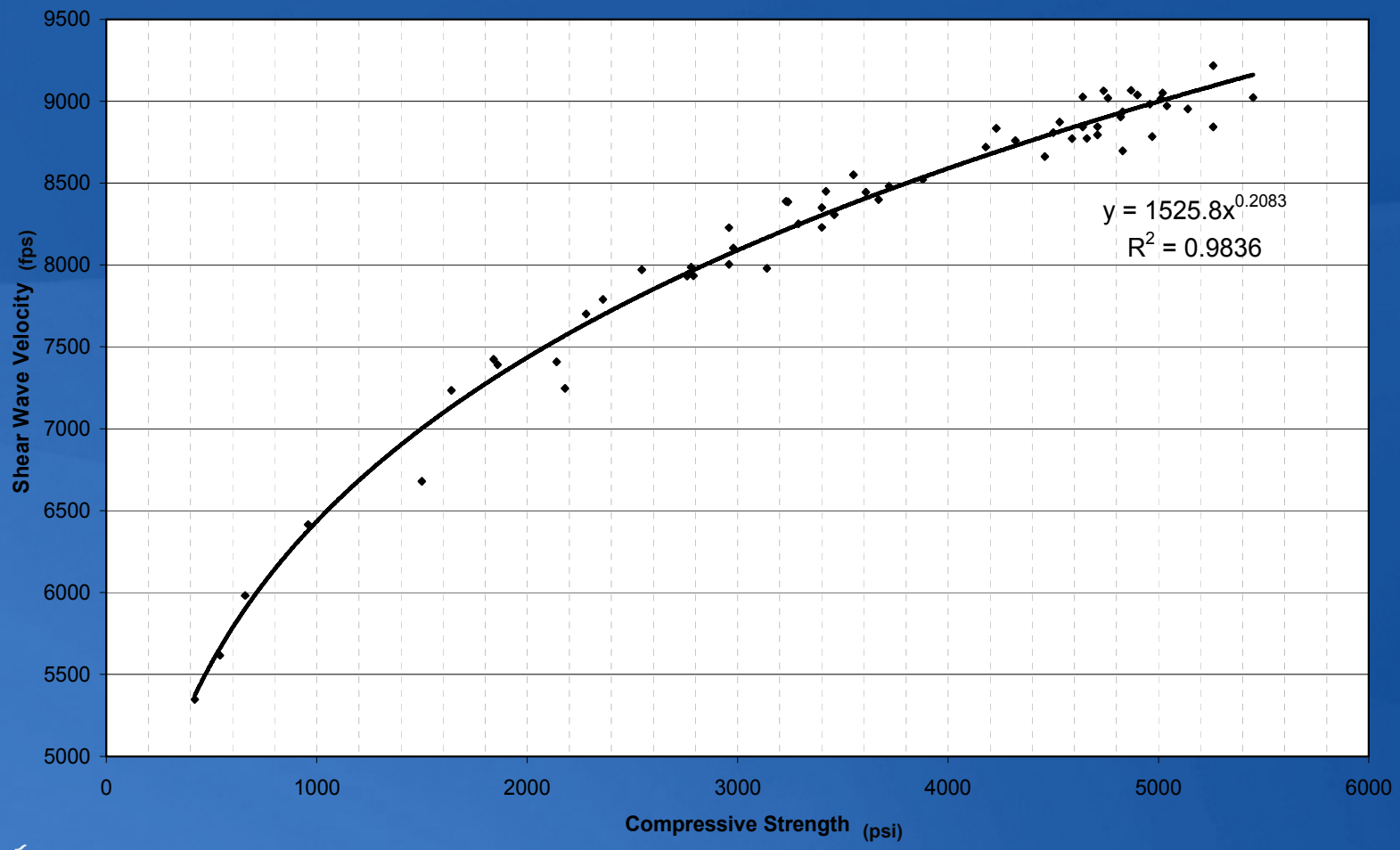
- Directly on native (*in-situ*) material (rock or soil)
- On concrete
- On shallow soil leveling course
- On deep engineered backfill

Cases 1 and 2 – No Fill or Concrete Fill

Where Category I structures are founded on either native material (soil or rock) or on concrete fill, *in-situ* measurement of SWV is not necessary

- SWV of native material is measured and reported in Section 2.5.4 of the FSAR
- SWV of concrete is >> 1,000 fps
- Confirmatory testing is not necessary to demonstrate that the SWV of foundation material meets the Tier 1 site parameter in the DCD

Concrete SWV (example)



Boone, 2005

Case 3 – Shallow Soil Leveling Course

Where Category I structures are founded on minimal (approx. ≤ 5 feet thickness) soil fill material placed upon native material as dental fill (isolated areas) or as a leveling course, *in-situ* SWV measurement is not necessary

- SWV of native material is measured and reported in Section 2.5.4 of the FSAR
- SWV of the specified backfill material will be established prior to construction through analysis and laboratory testing (e.g., RCTS)
- Placement methods and compaction requirements for the dental or leveling course will be specified and verified during construction
- Given the minimal thickness of this leveling layer under the structure, its SWV will have a minimal impact on the performance of the overlying structure under static and dynamic conditions

Case 4 – Significant Soil Fill

Where Category I structures are founded on significant (approx. > 5 feet thickness) engineered soil backfill, *in-situ* SWV measurement of the backfill will be performed

- SWV of native material is measured and reported in Section 2.5.4 of the FSAR
- SWV of the specified backfill material will be established prior to construction, particularly as it relates to confining pressure
- Placement methods and compaction requirements for backfill under Category I structures will be specified and verified during construction
- Where the depth of the fill under the structure is significant enough to impact either the site response or the dynamic response of the structure, the SWV will be measured *in-situ* and analyzed to demonstrate and verify that the Tier 1 site parameter is met

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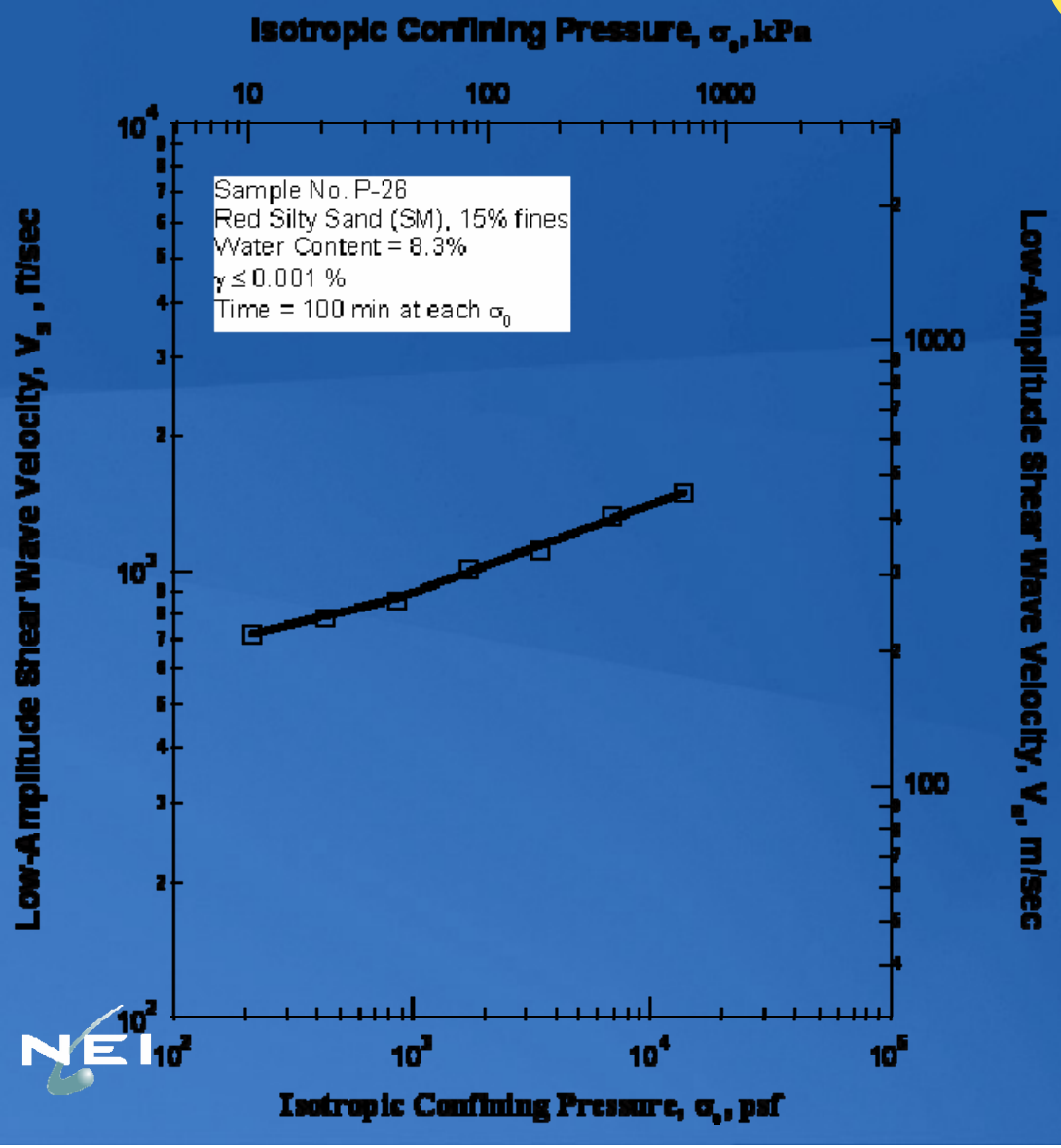
Variation in SWV with Confining Pressure (σ_o)



SWV increases with increasing confining pressure; therefore, *in-situ* SWV depends on:

1. Depth within soil profile
2. Weight of any overlying structure

Field Confirmation Challenges

Confirmation that SWV meets the Tier 1 site parameter is not a matter of simply taking and recording a few field measurements:

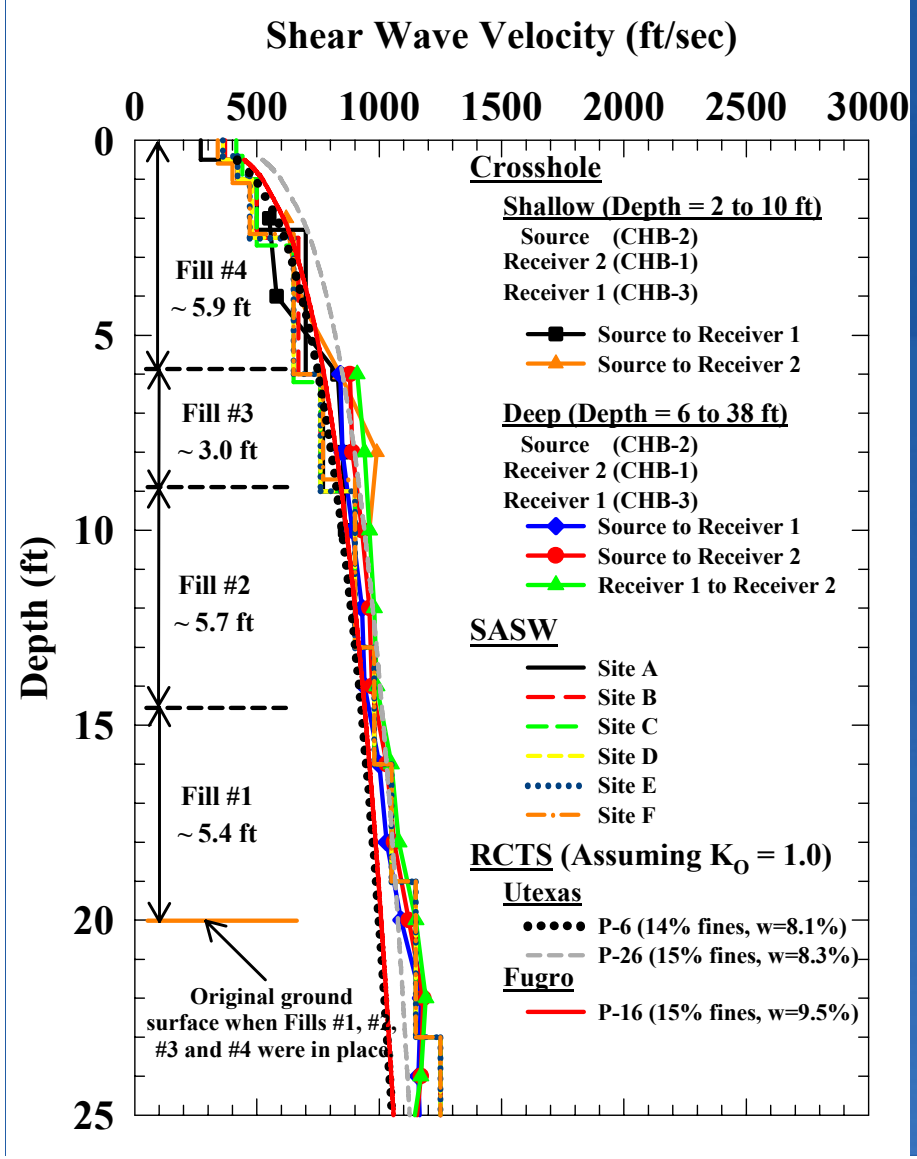
- A variety of methods are available to perform in-situ field measurements of SWV in soil fill, including (but not limited to): Crosshole, SASW, and Seismic CPT
- Where it is not possible to make in-situ field measurements of SWV, laboratory test measurements on reconstituted samples can be carried out via RCTS
- Testing directly under a Category I foundation is not possible if effect of structure weight on confining pressure is to be considered

Field Confirmation Challenges (cont.)

- Measurement protocol may depend on site-specific conditions (e.g., access, excavation geometry)
- Since each of the DCDs specify SWV requirements in a different manner and since each site is unique with varying construction and site issues, the measurement methodology may differ by DCD and from site to site
- Methodology for analysis of test results to confirm that the Tier 1 SWV site parameter is met will vary depending upon the DCD being utilized and the particular site characteristics

Consequently, confirmation that SWV meets the Tier 1 site parameter will require a combination of field measurement and engineering analysis.

Insights Gained From Field SWV Measurement



- SWV increases with increasing confining pressure
- SWV profiles from SASW and Crosshole seismic tests show excellent agreement
- The COV is very small, confirming that a homogeneous fill can be achieved with controlled material and placement procedures
- SWV values from laboratory RCTS tests fit the field profiles well

Source: Vogtle Test Fill

Proposed Generic ITAAC for SWV

Generic ITAAC for Backfill Shear Wave Velocity of Significant Backfill Placed under Category I Structures

Design Commitment	Inspection, Tests and Analyses	Acceptance Criteria
Shear Wave Velocity of backfill material meets the site parameter specified in the Tier 1 of the DCD.	Field measurements and analyses of shear wave velocity in backfill will be performed.	An engineering report exists which concludes that the shear wave velocity within the backfill material placed under Seismic Category I structures meets the site parameter specified in Tier 1 of the DCD.

The methodology and plan for accomplishing the SWV inspection, tests and analyses (ITA) will be described in the FSAR.

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Conclusions and Wrap-Up

- Cases where confirmatory SWV measurement is appropriate
- SWV ITAAC language
- Actions items
- Other related issues