In Situ Measurement of Dynamic Properties for Seismic Site Response Analysis of Mine Tailings Dams

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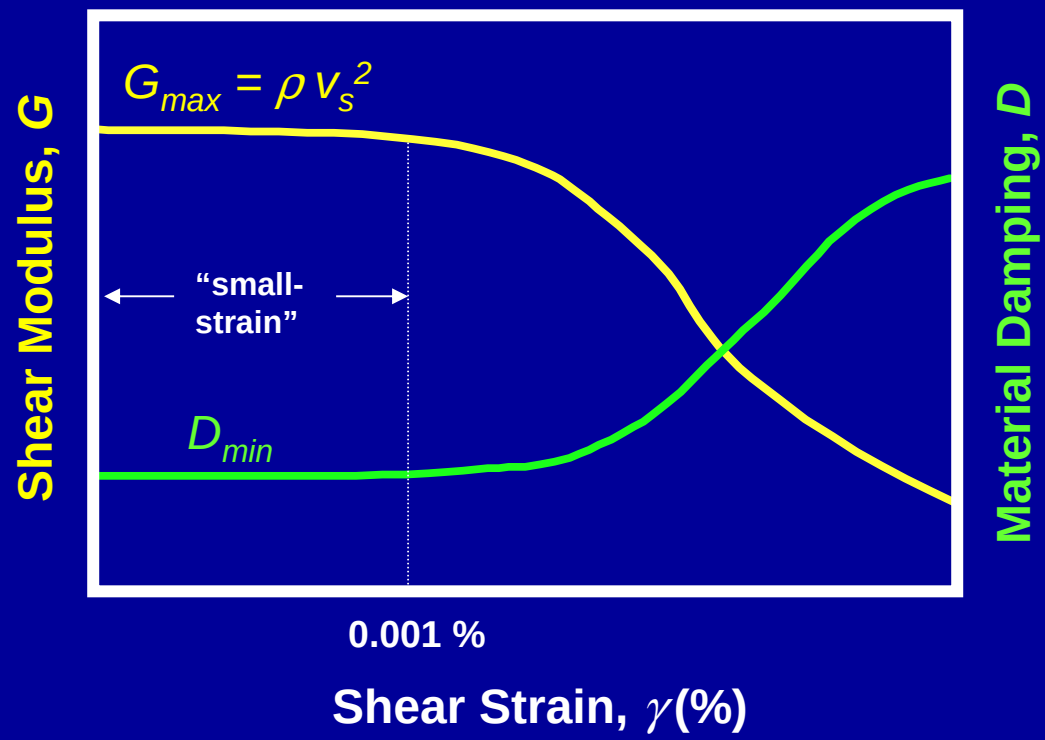
IN SITU DYNAMIC SOIL PROPERTIES

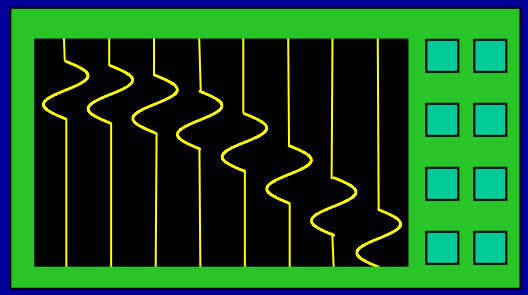


NON-INTRUSIVE IN SITU MEASUREMENTS

- Reflection Seismic
- Refraction Seismic
- Surface Waves

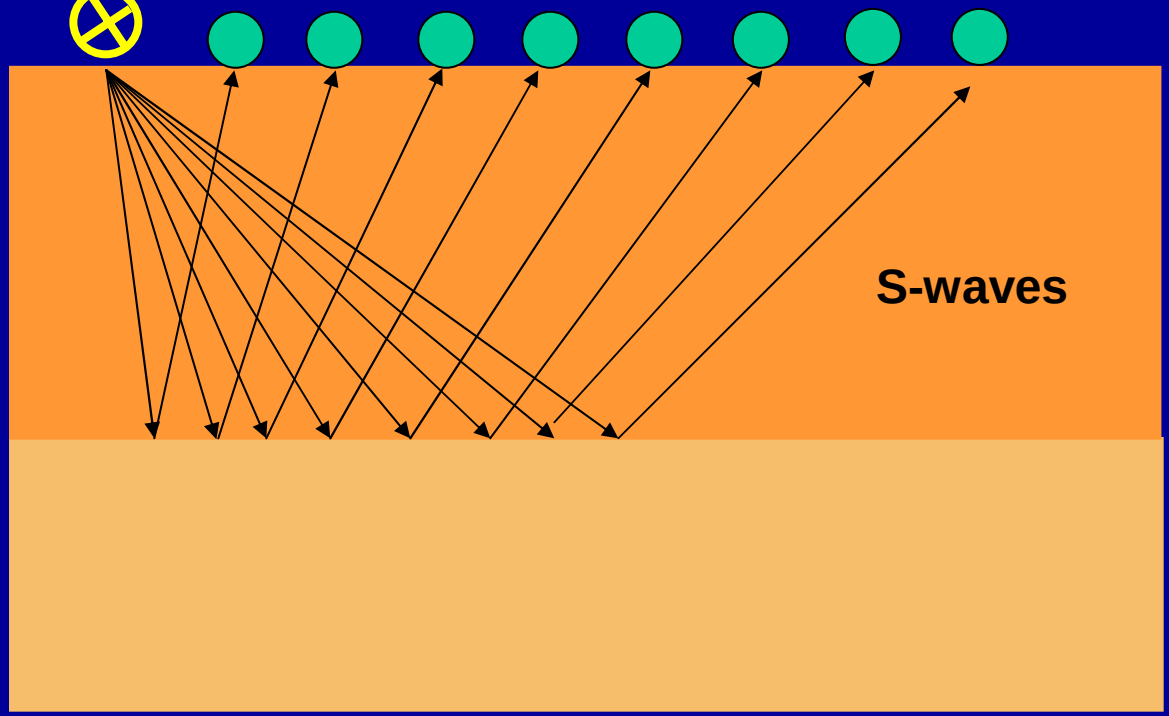
Reflection Seismic Method

Multiple-Channel Seismograph



Horiz. Source

Horizontal Geophones (24+)



Layer 1, $Z_1 = \rho_1 V_{s1}$

Layer 2, $Z_2 = \rho_2 V_{s2}$

$Z_1 \neq Z_2$

Reflection Seismic Method

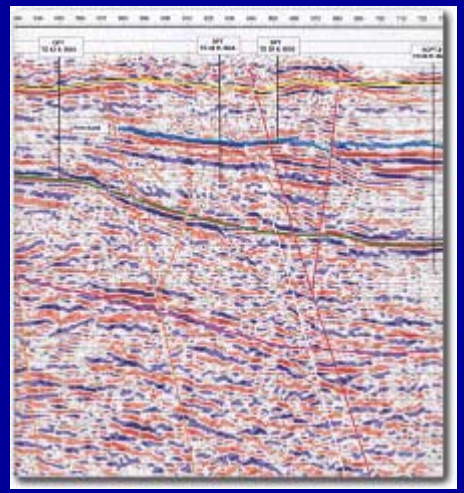
Seismic Sources

Geophone Deployment

Acquisition Instrument

distance

depth



Processed Cross-Section

Reflection Seismic Method

Advantages

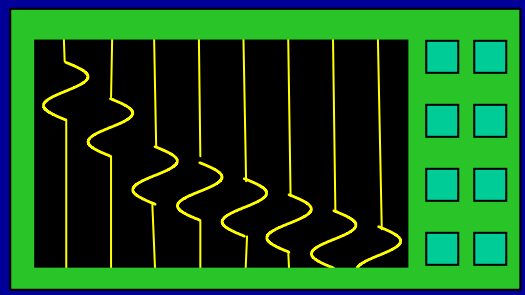
- provides subsurface structural detail
- provides velocity information
- “unlimited” depth of investigation

Disadvantages

- data analysis is subjective
- Generating and recording S-waves is more difficult
- large volumes of data required

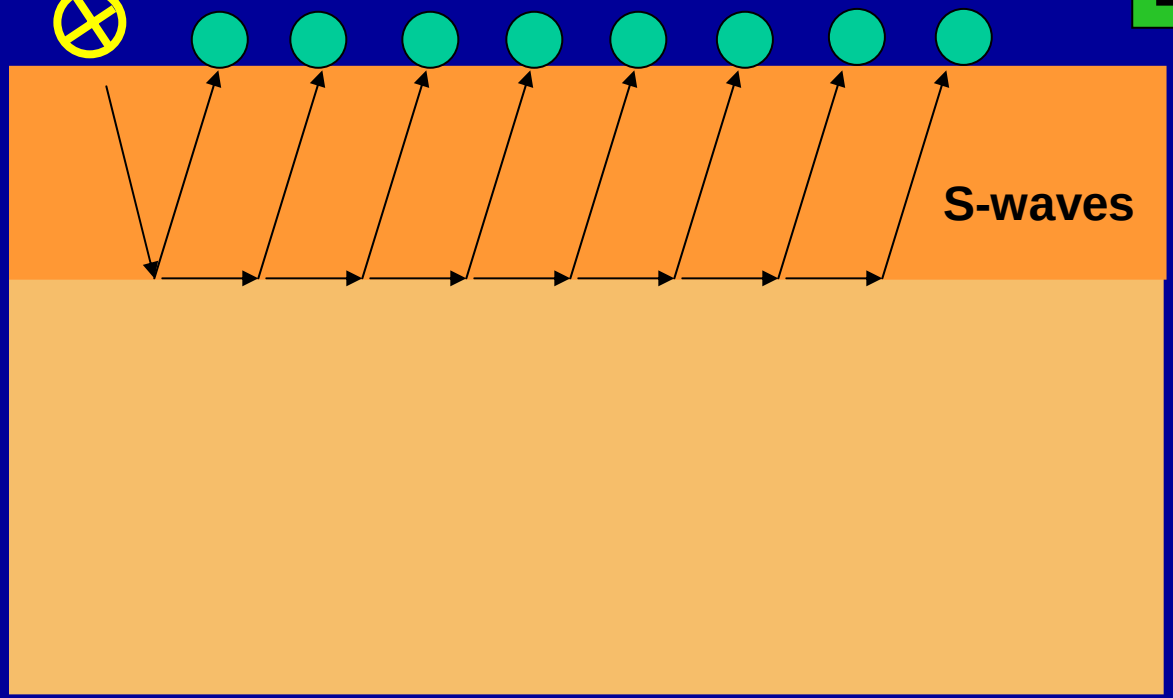
Refraction Seismic Method

Multiple-Channel Seismograph



Horiz. Source

Horizontal Geophones (24+)

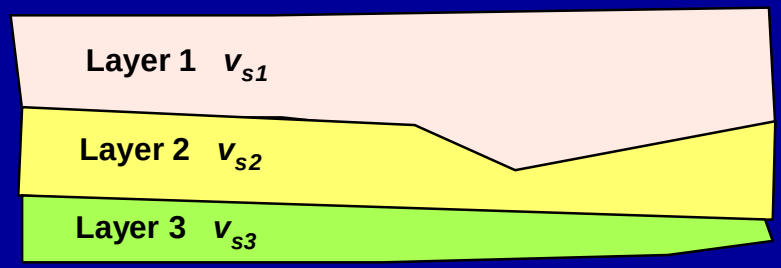


Refraction Seismic Method

Seismic Sources

Geophone Deployment

Acquisition Instrument



Typical Cross-Section

Refraction Seismic Method

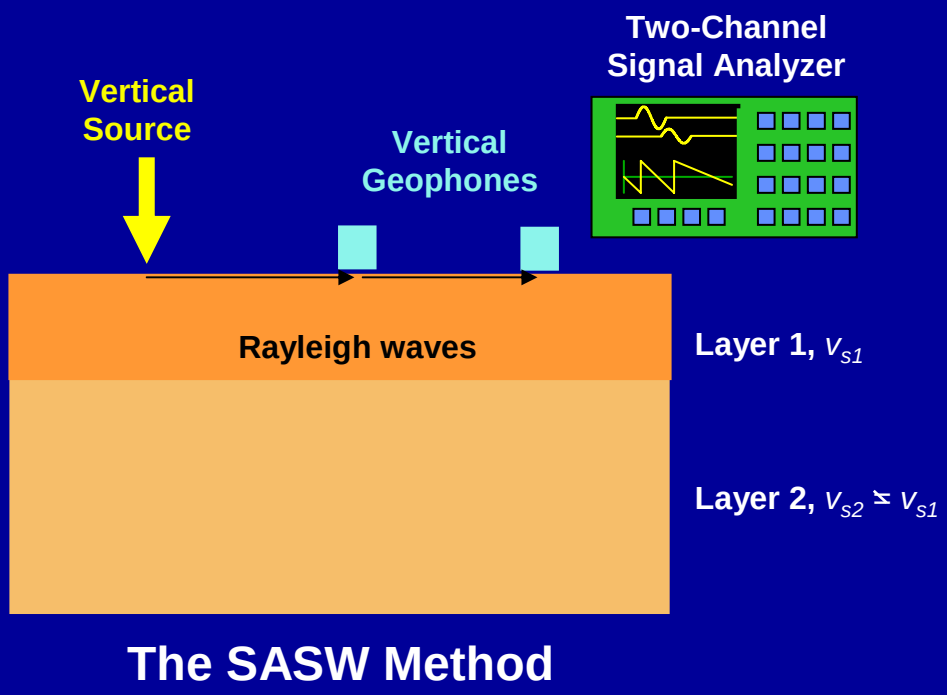
Advantages

- analysis methods range from simple to complex
- tomographic technology is catching up to reflection seismic

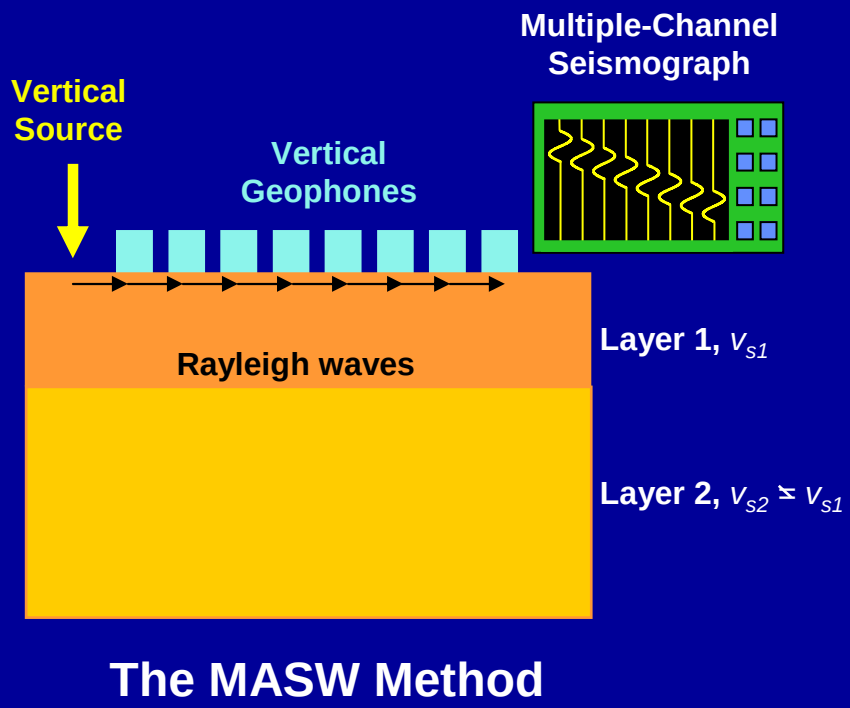
Disadvantages

- Issues with thin layers and velocity inversions
- Generating and recording S-waves is more difficult

Surface Wave Methods



The SASW Method

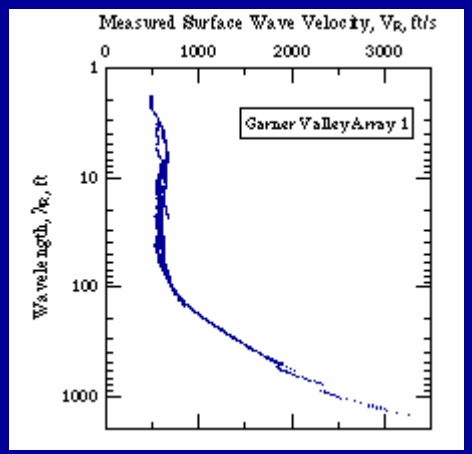


The MASW Method

Surface Wave Methods

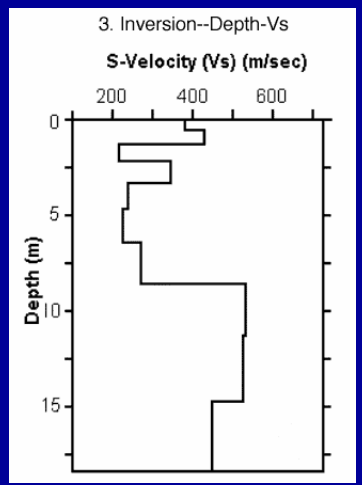
SASW Data Acquisition

MASW Data Acquisition



Field dispersion curve

INVERSION



v_s profile

Surface Wave Methods

Advantages

- Quick, simple tool for v_s measurement
- Automatic dispersion curve generation with MASW method

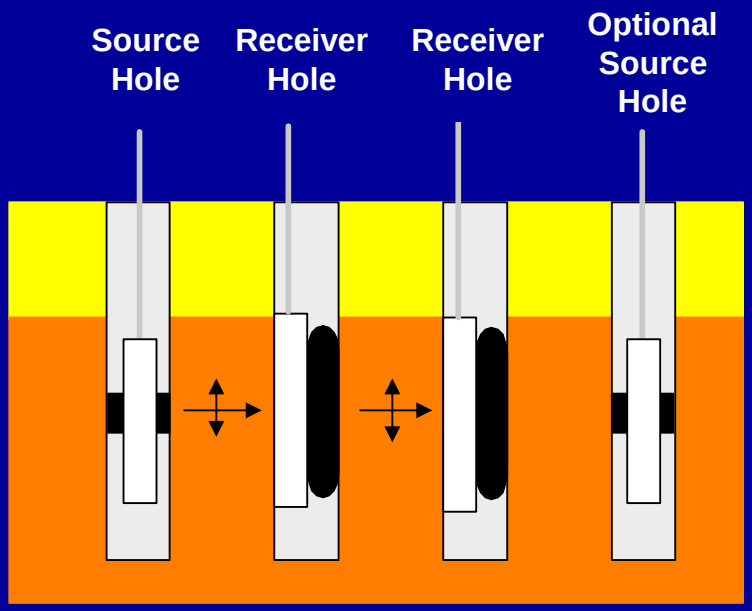
Disadvantages

- SASW analysis is subjective
- Depth of investigation limited to less than 200 ft
- Cannot resolve lateral variations in v_s

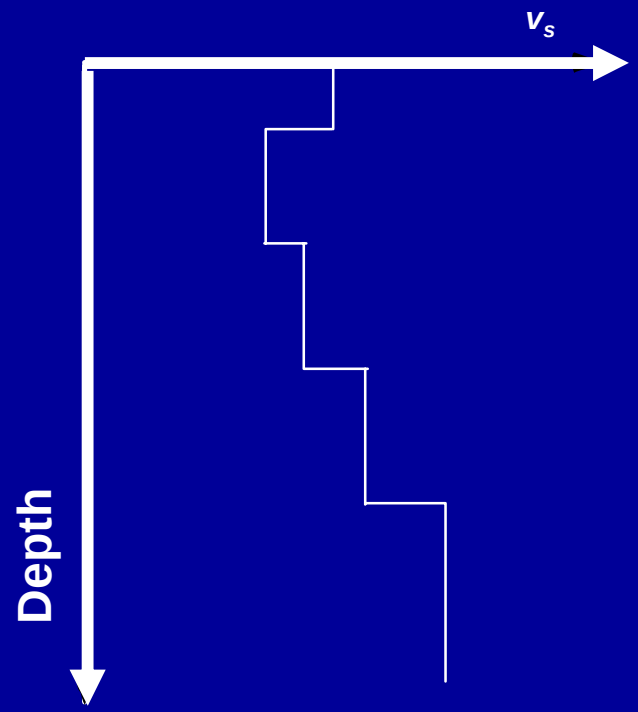
INTRUSIVE IN SITU MEASUREMENTS

- Crosshole Seismic
- Downhole Seismic
- Seismic CPT
- Suspension Logger

Crosshole Seismic



Data acquisition

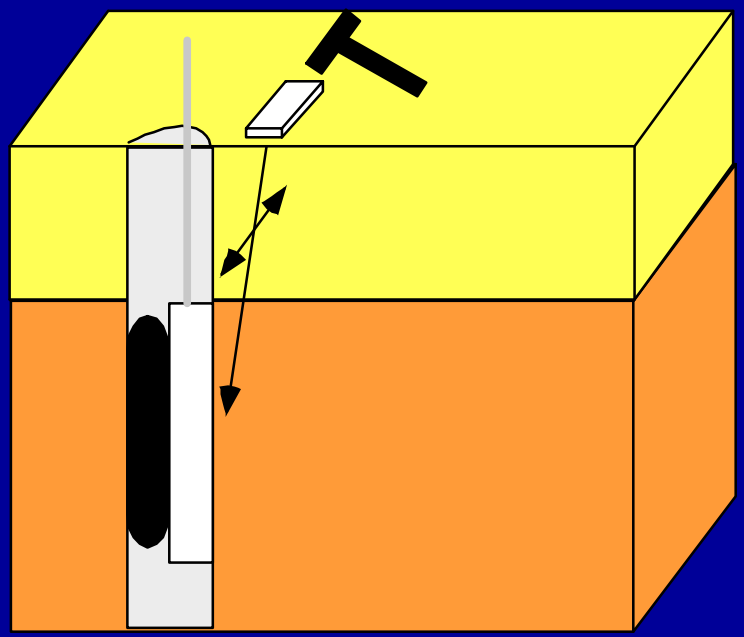


Results

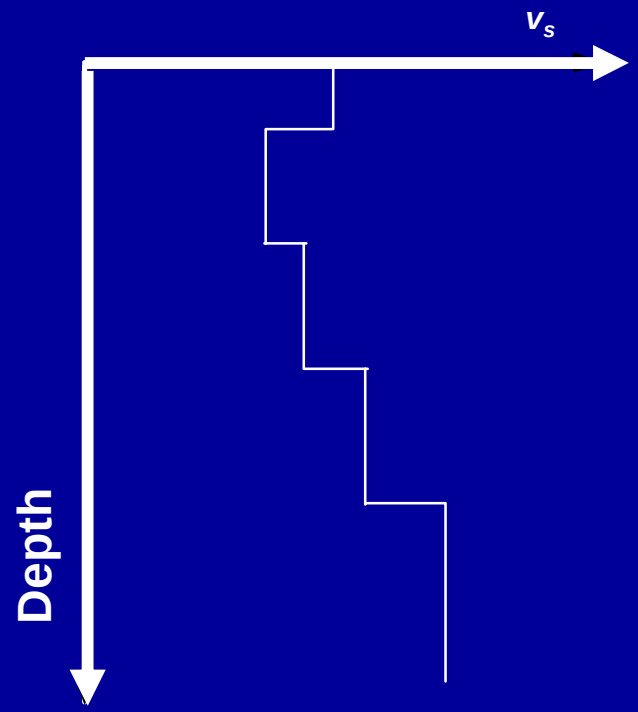
Points to consider:

- **Requires installation of 3 or more boreholes**
- **Can measure D_{min} with 4 holes**
- **Need directional survey for depth > 20 ft**

Downhole Seismic



Data Acquisition



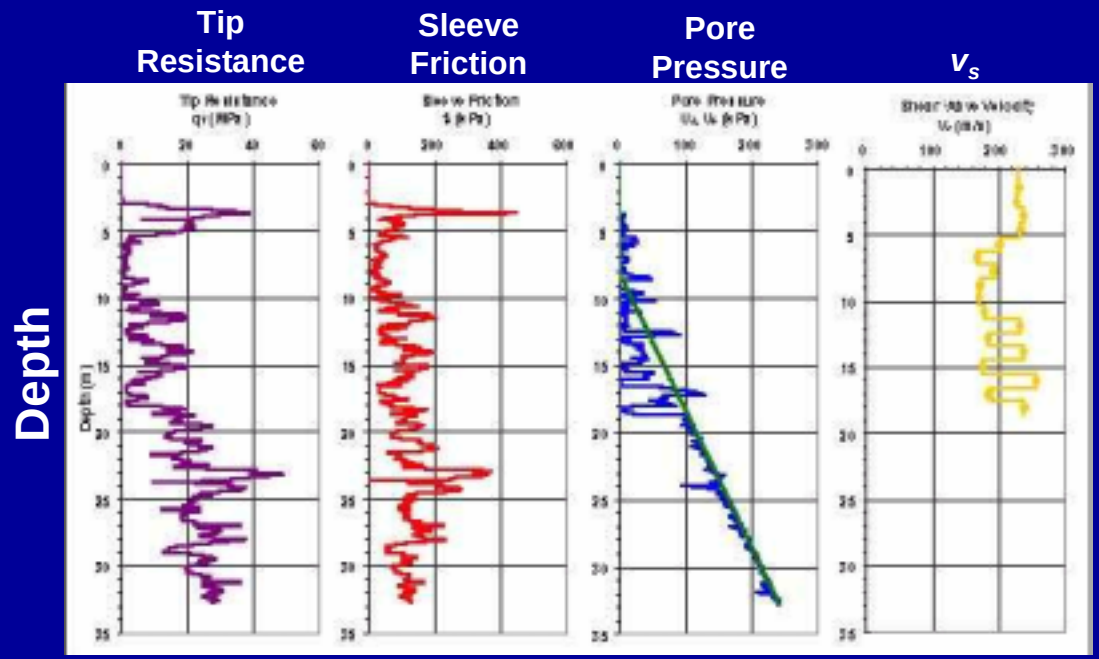
Results

Points to consider:

- **Requires installation of only one borehole**
- **May be depth-limited**

Seismic CPT

Data acquisition

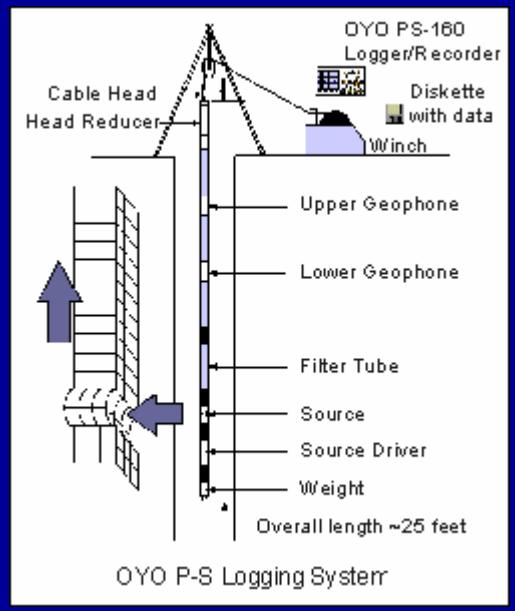


Results

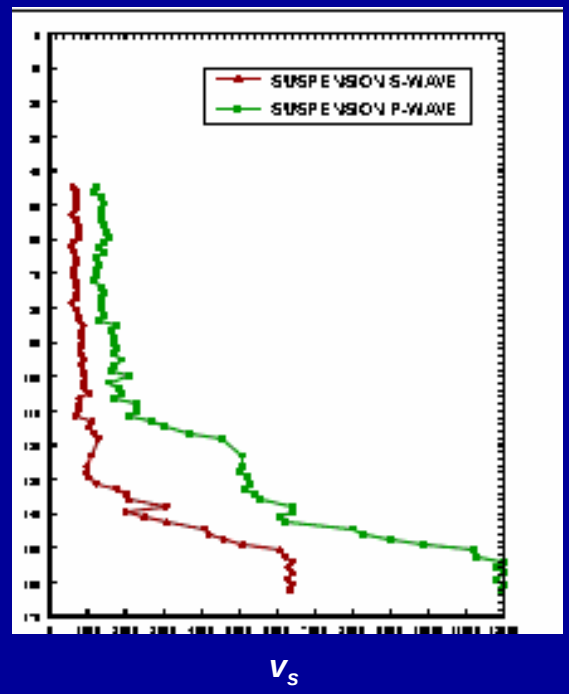
Points to consider:

- **Provides highly-resolved data**
- **Provides information for liquefaction analysis**

PS Suspension Logger



Data acquisition



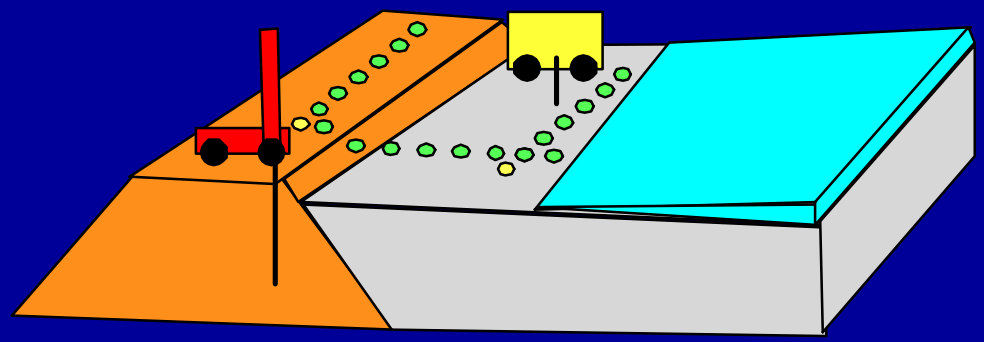
Results

Points to consider:

- **Provides highly-resolved data**
- **Operates in uncased fluid-filled borehole**

SELECTION OF APPROPRIATE METHODS

- Use more than one method
- Perform pre-survey modeling
- Different methods require different site access
- Borehole installation may be required
- Excessive vibration amplitudes may be generated



Example:
1 downhole test on dam
1 Seismic CPT on beach
2 MASW lines
1 Refraction seismic line

THANK YOU

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