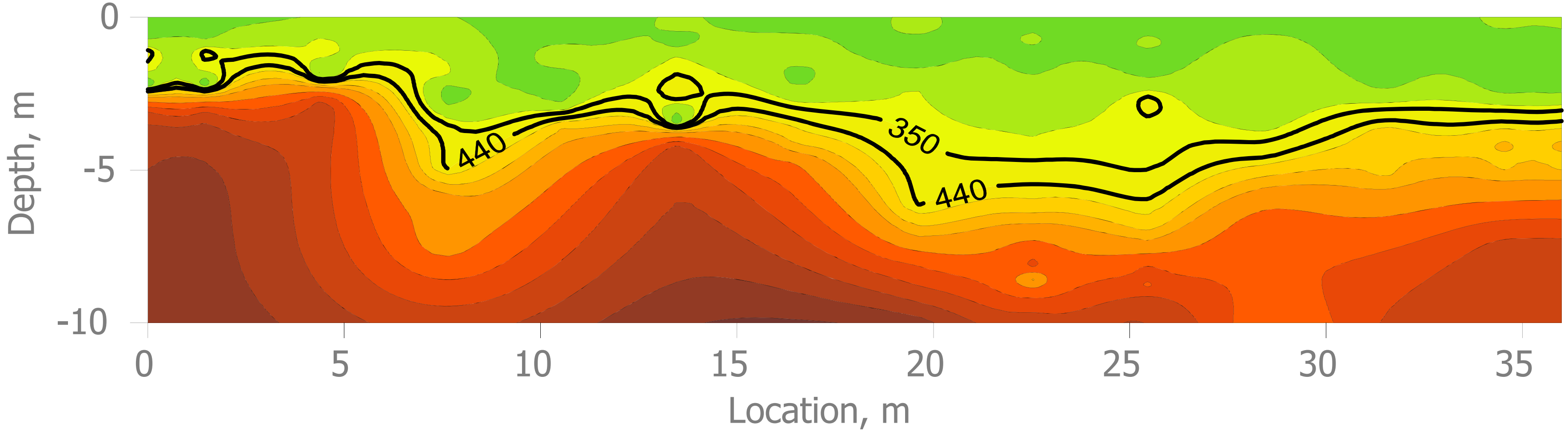
Nov. 17, 2015

Spectral-Analysis-of-Surface-Waves (SASW) Method

Surface Wave Techniques to Evaluate Subsurface Stiffness Structure



Sung-Ho Joh

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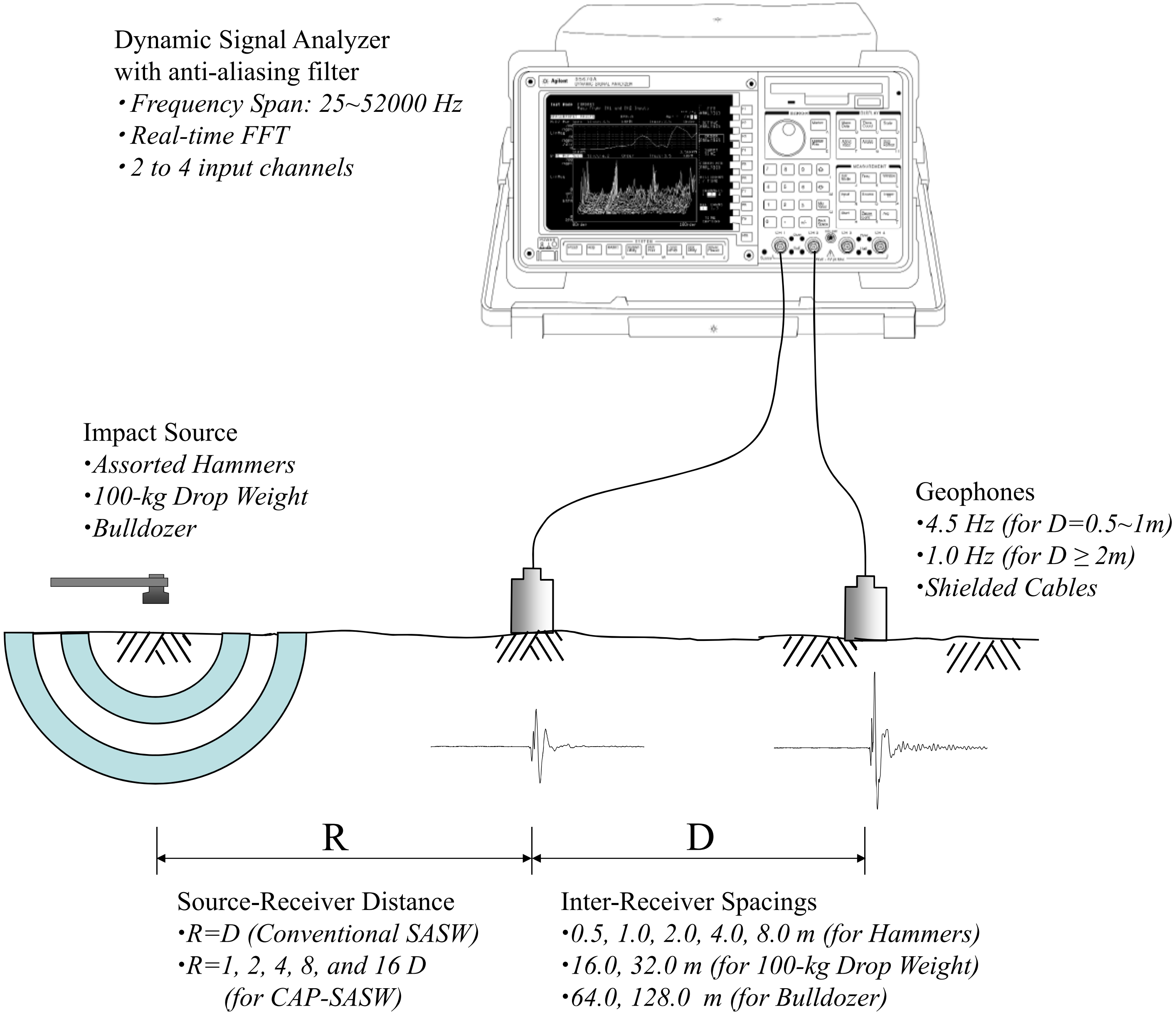
Chung-Ang University

Principles and Concepts of the SASW Method

Setup for SASW Measurements

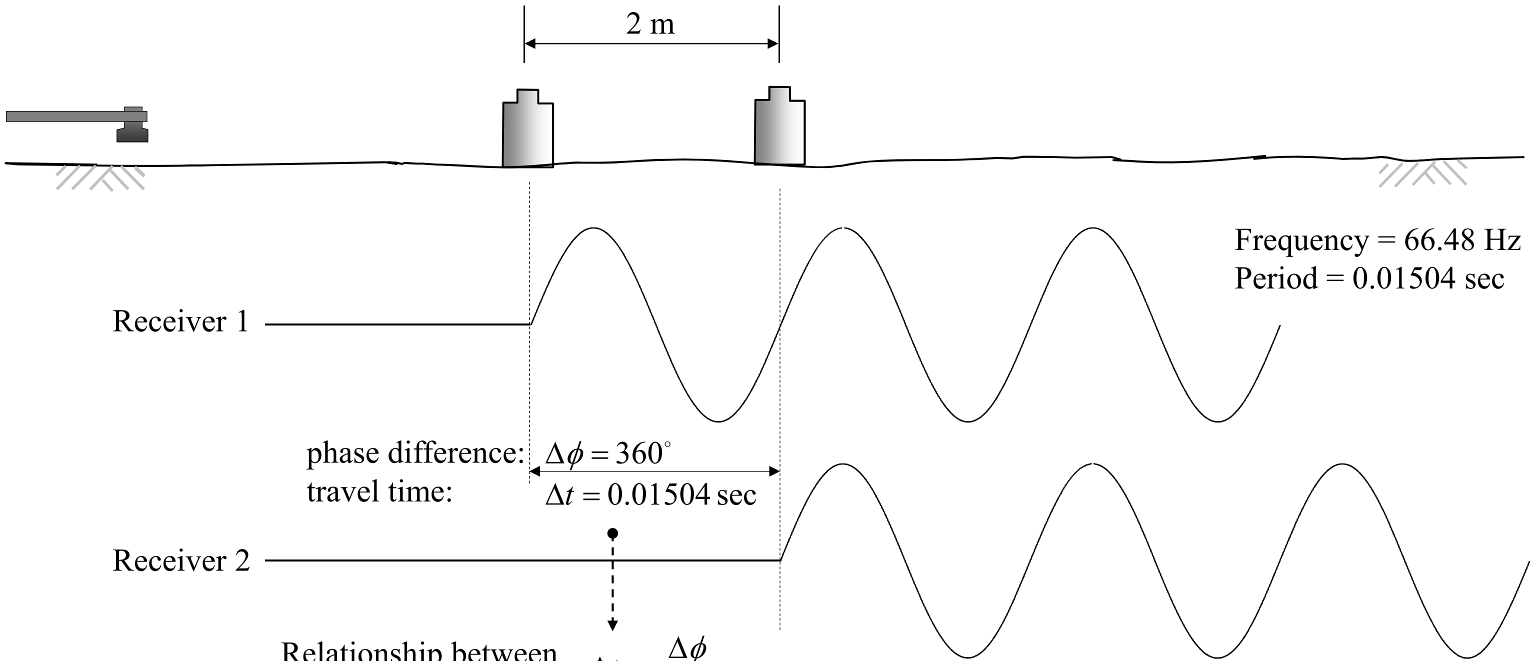


- FFT Analyzer

- Geophones

- Seismic Sources

Principles of Phase-Velocity Measurement

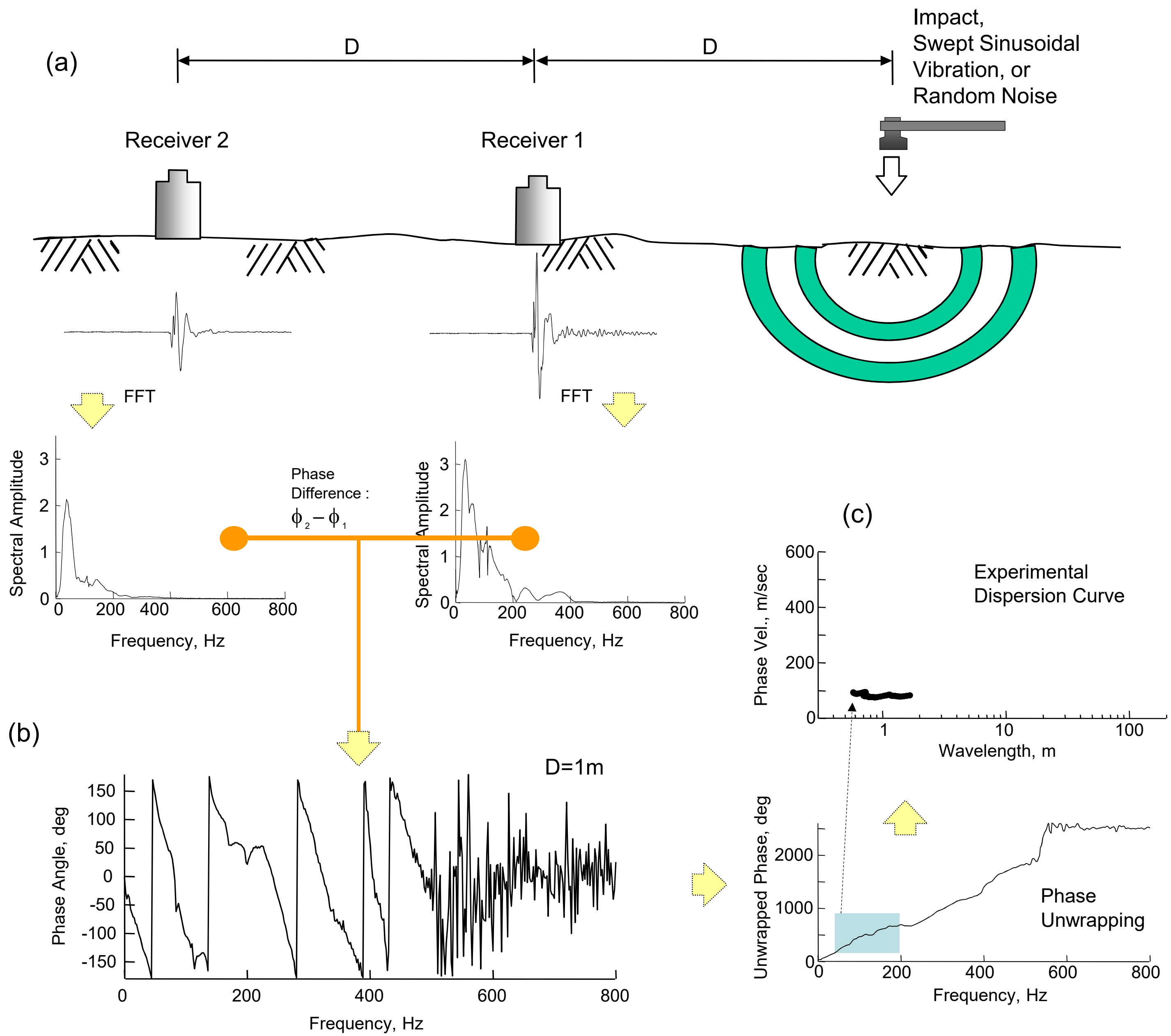


Relationship between $\Delta\phi$ and Δt : $\Delta t = \dfrac{\Delta\phi}{2\pi\ f}$

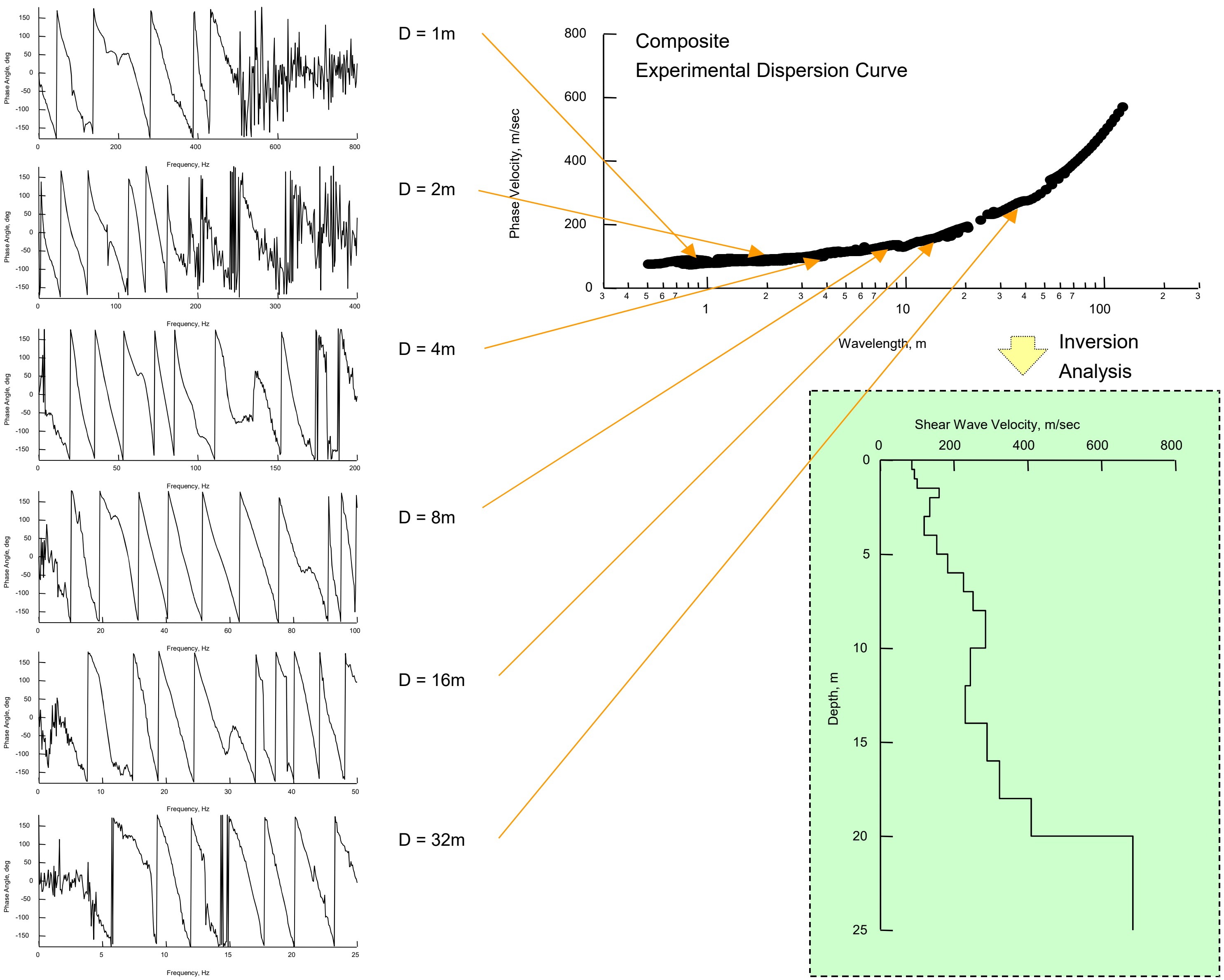
Phase Velocity: $v_{ph} = \dfrac{D}{\Delta t} = \dfrac{2.0}{0.01504} = 133.0$ m/sec

$$v_{ph} = \frac{2\pi\ fD}{\Delta\phi}$$

Phase-Velocity Determination in SASW Method

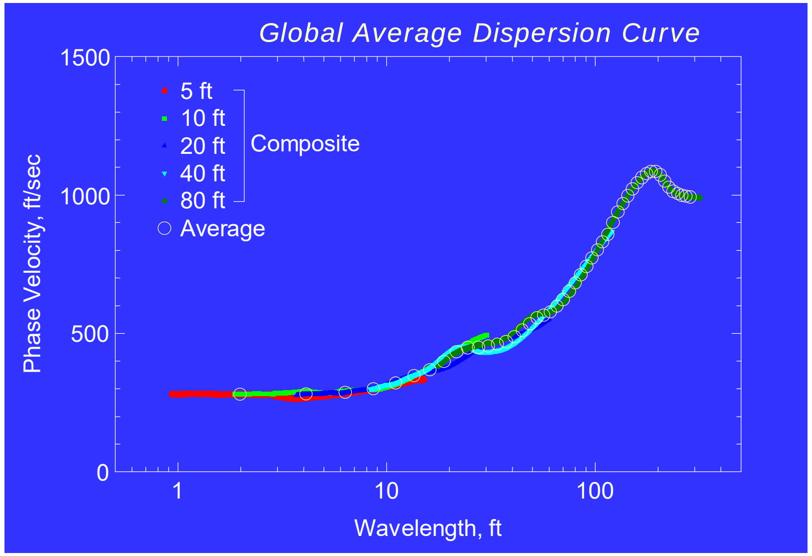


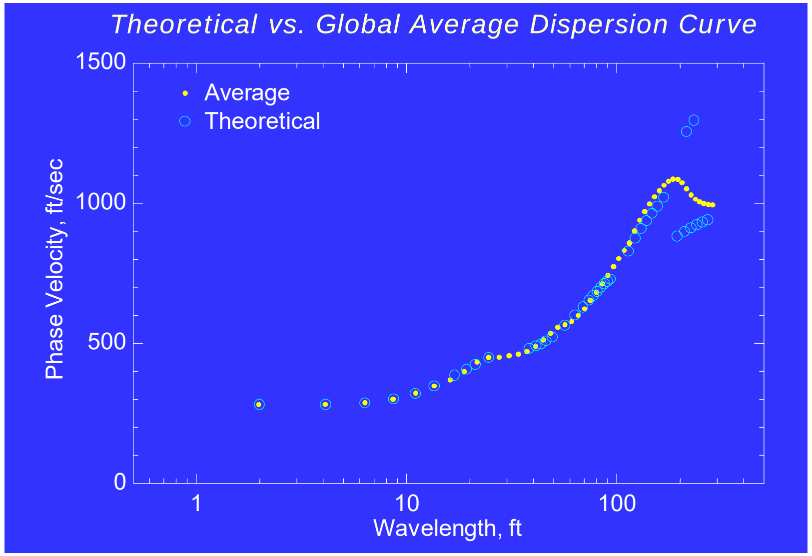
Inversion Analysis in the SASW Method



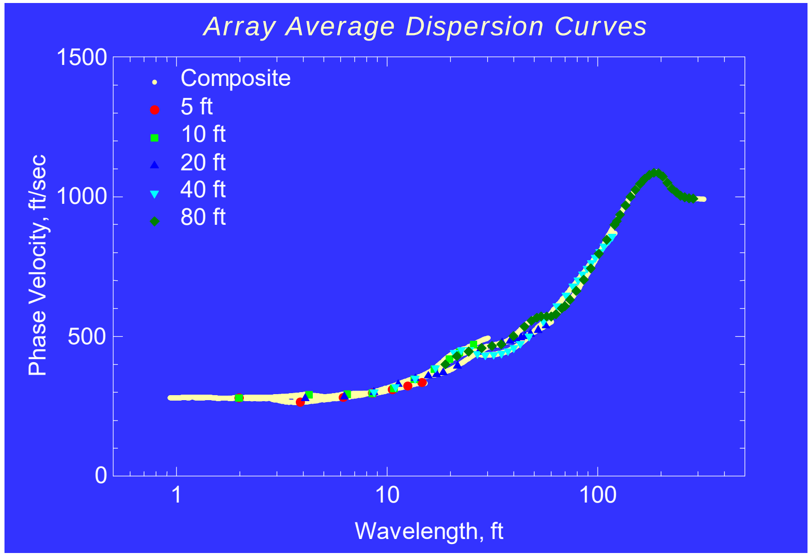
Inversion Analysis for the SASW Method: *Global and Array Inversion Analyses*

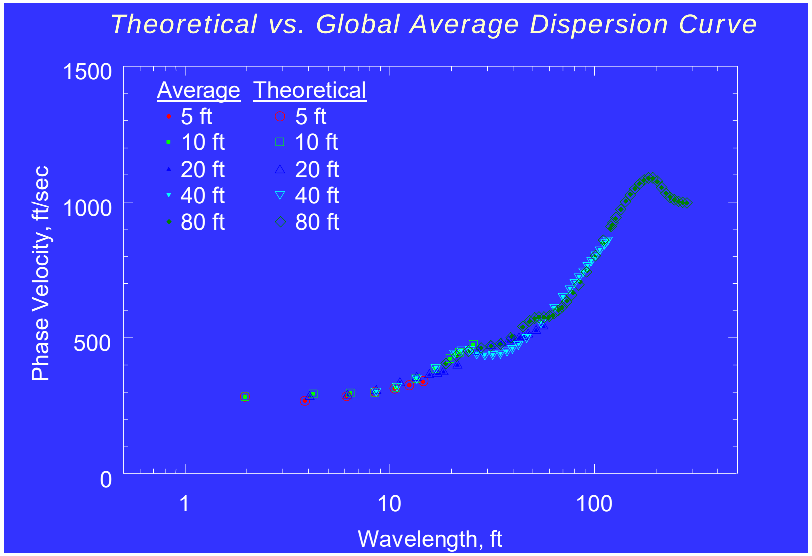
⦿ Dispersion Curve for Global Inversion Analysis





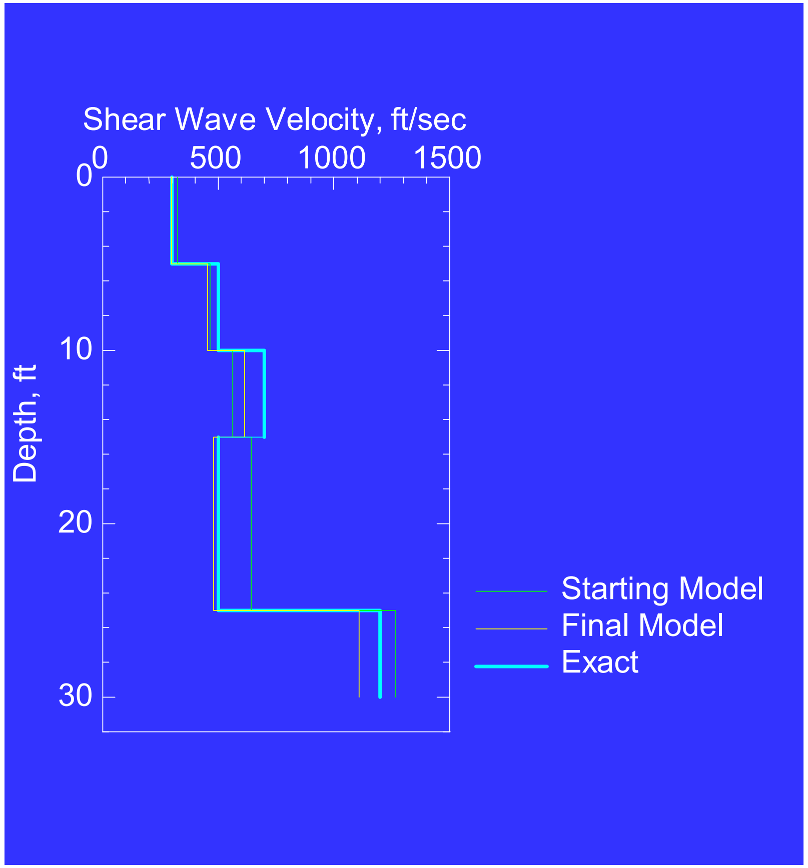
⦿ Dispersion Curve for Array Inversion Analysis



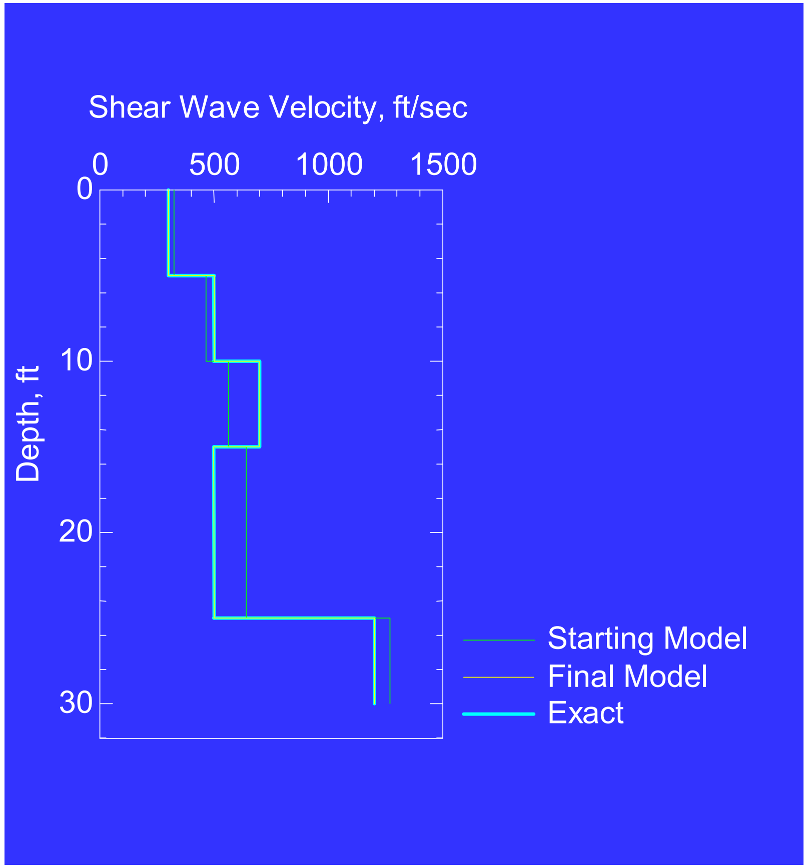


Inverted Shear-wave Velocity Profiles

◉ Global Inversion

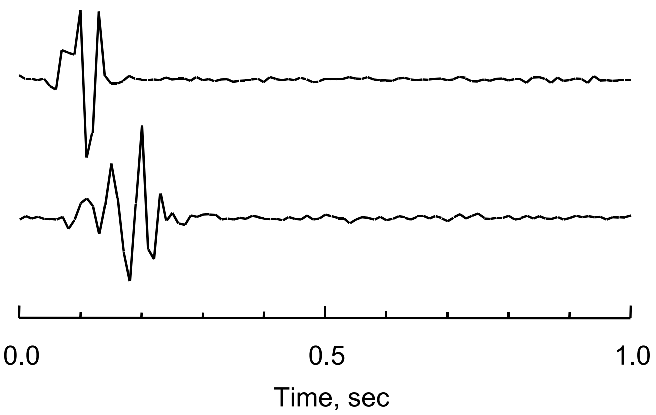


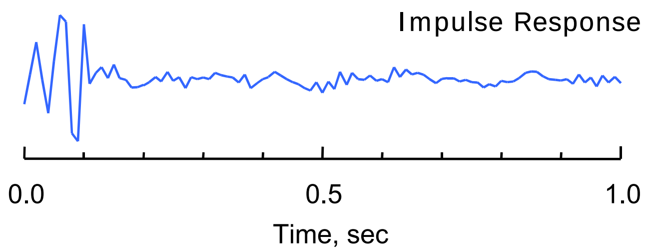
◉ Array Inversion

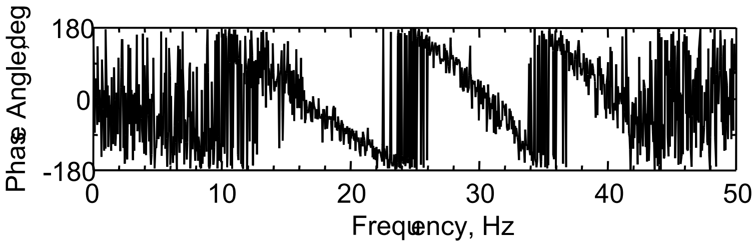


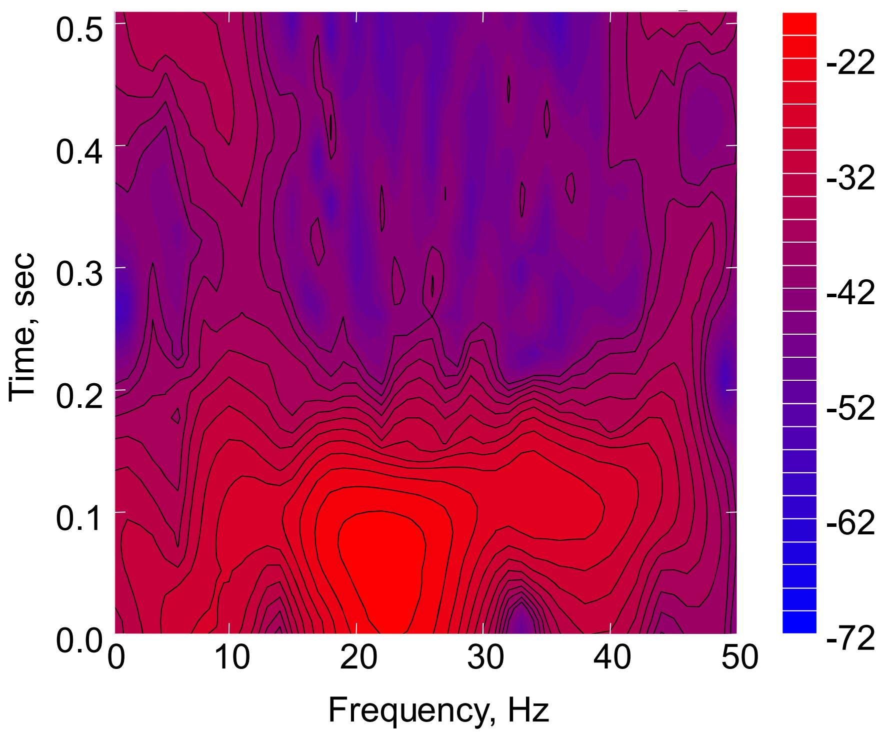
Impulse Response Filtration (IRF) Technique

- Random Noise Added to the Theoretically Determined Displacements

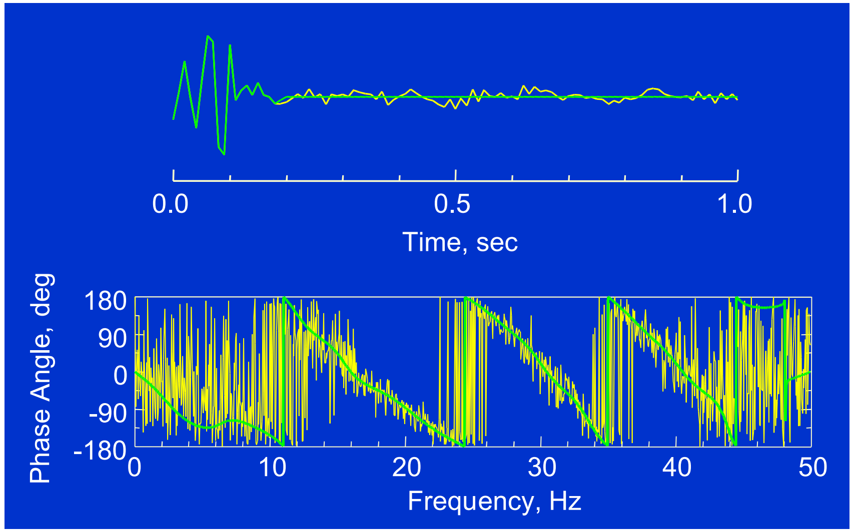


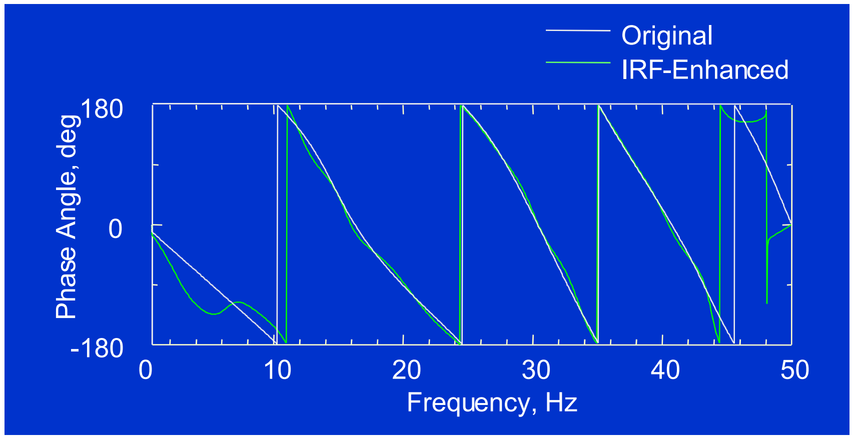


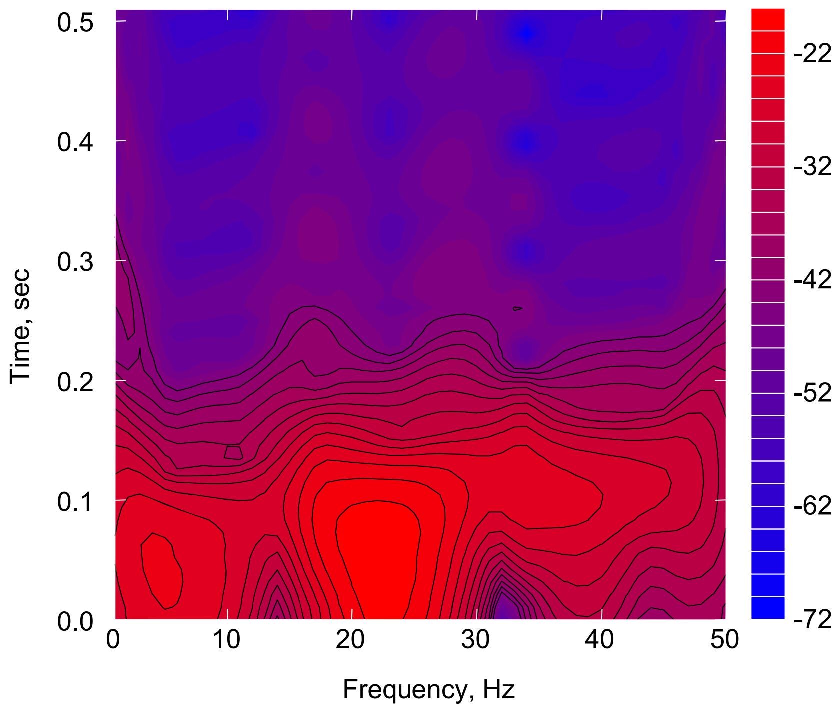




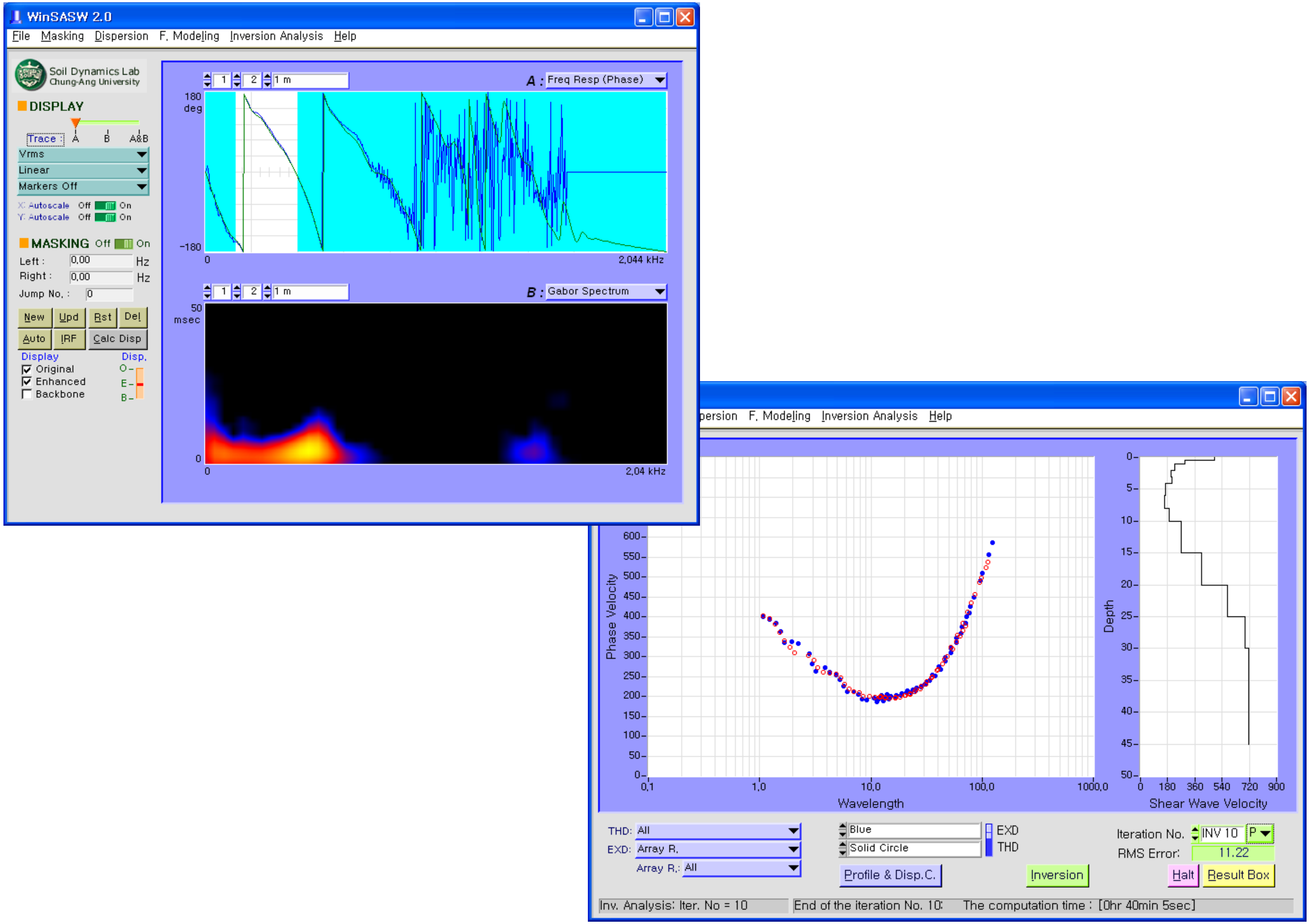
⦿ Comparison of the Original and IRF-Enhanced Phase Spectra





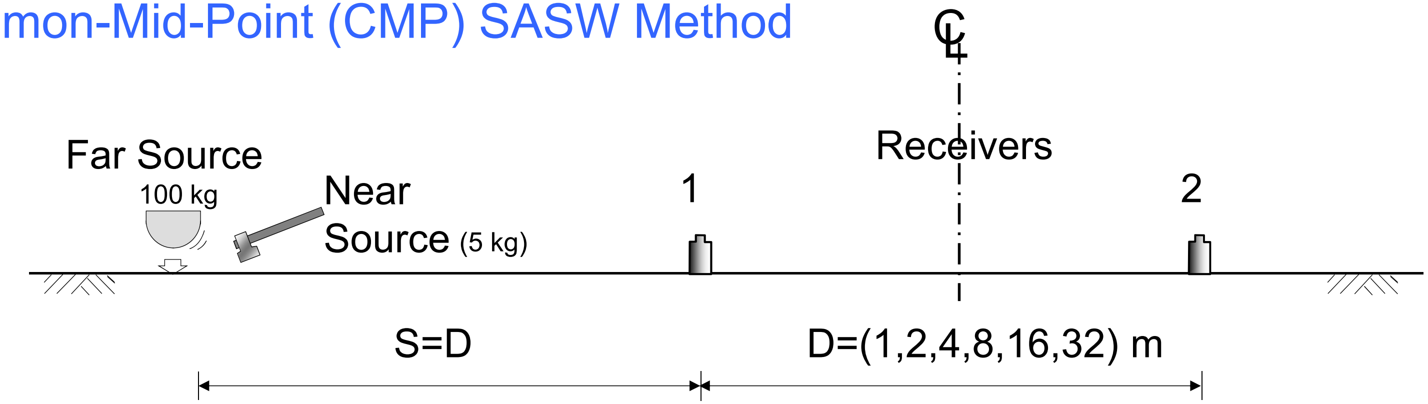


■ WinSASW, Dedicated Software for the SASW Method

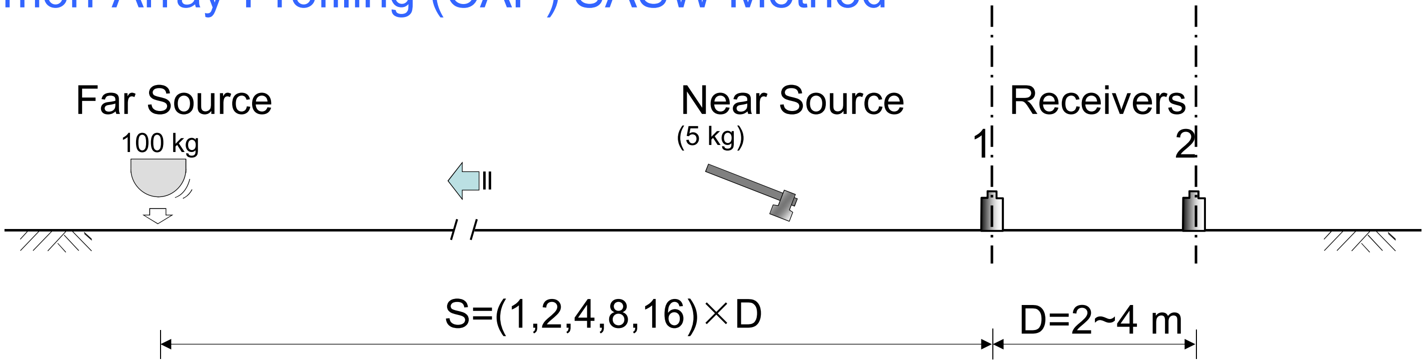


Recent Development in the SASW Method

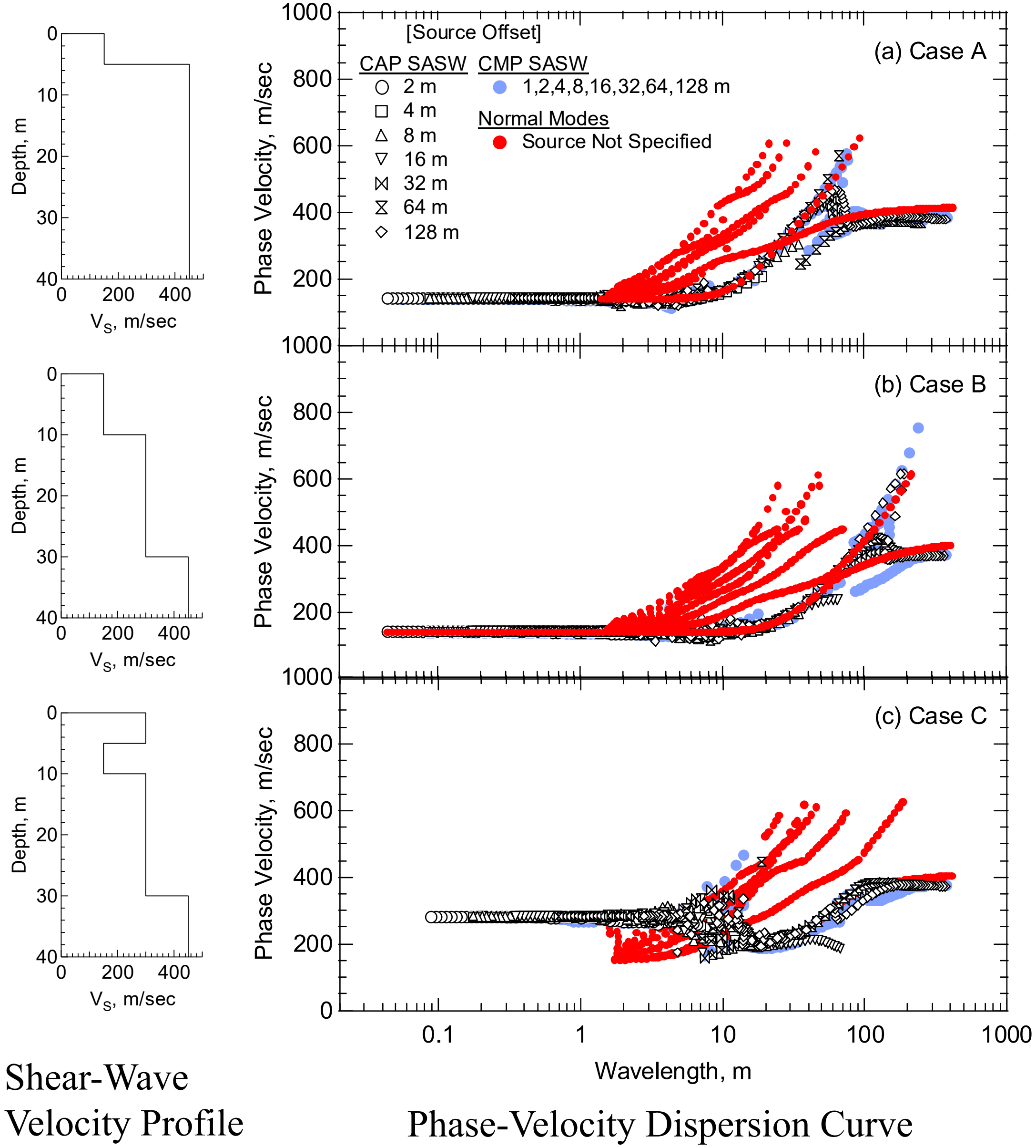
- Common-Mid-Point (CMP) SASW Method



- Common-Array-Profiling (CAP) SASW Method

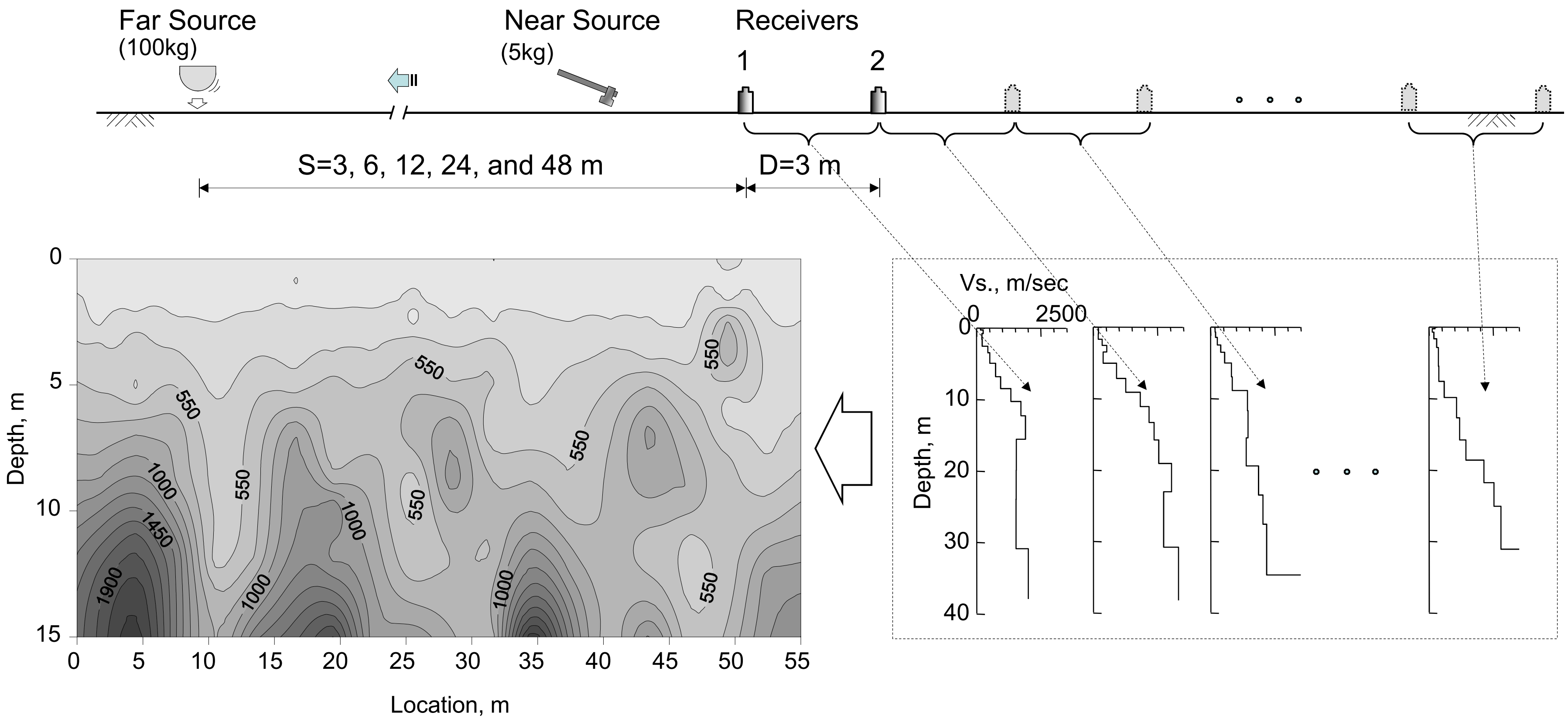


• CMP SASW Method vs. CAP SASW Method

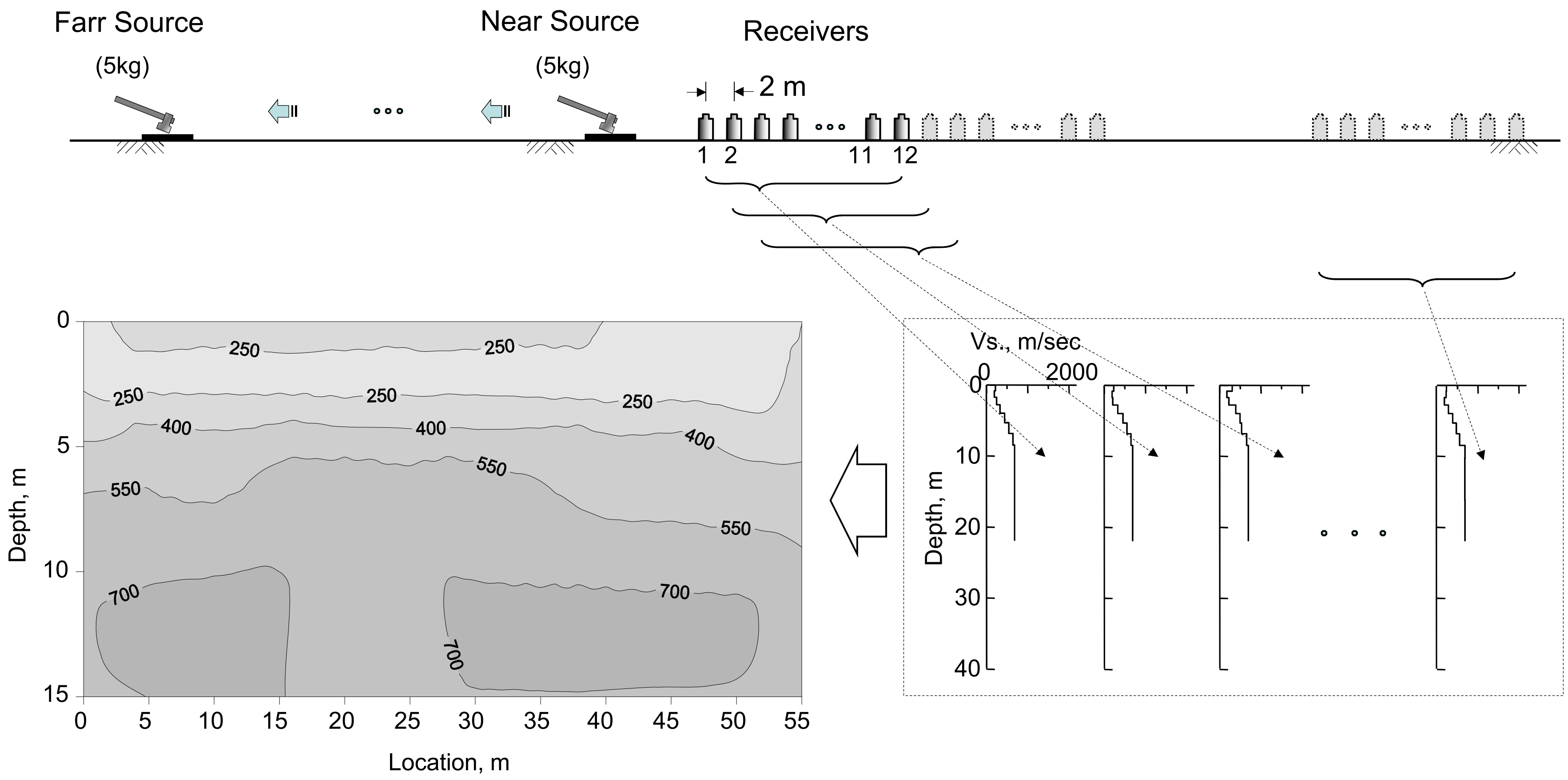


Evaluation of 2-D Shear-Wave Velocity Profiles

- CAP SASW Method

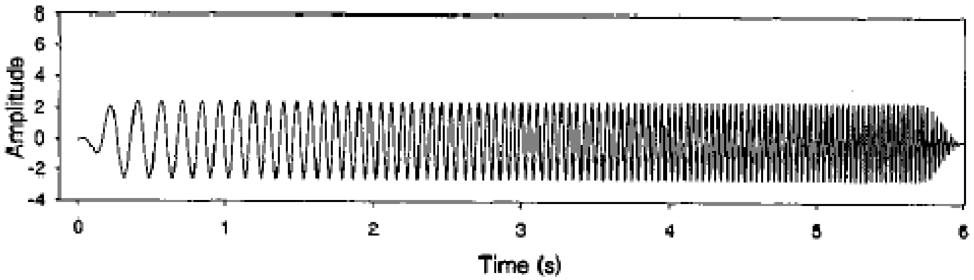


- MASW Method

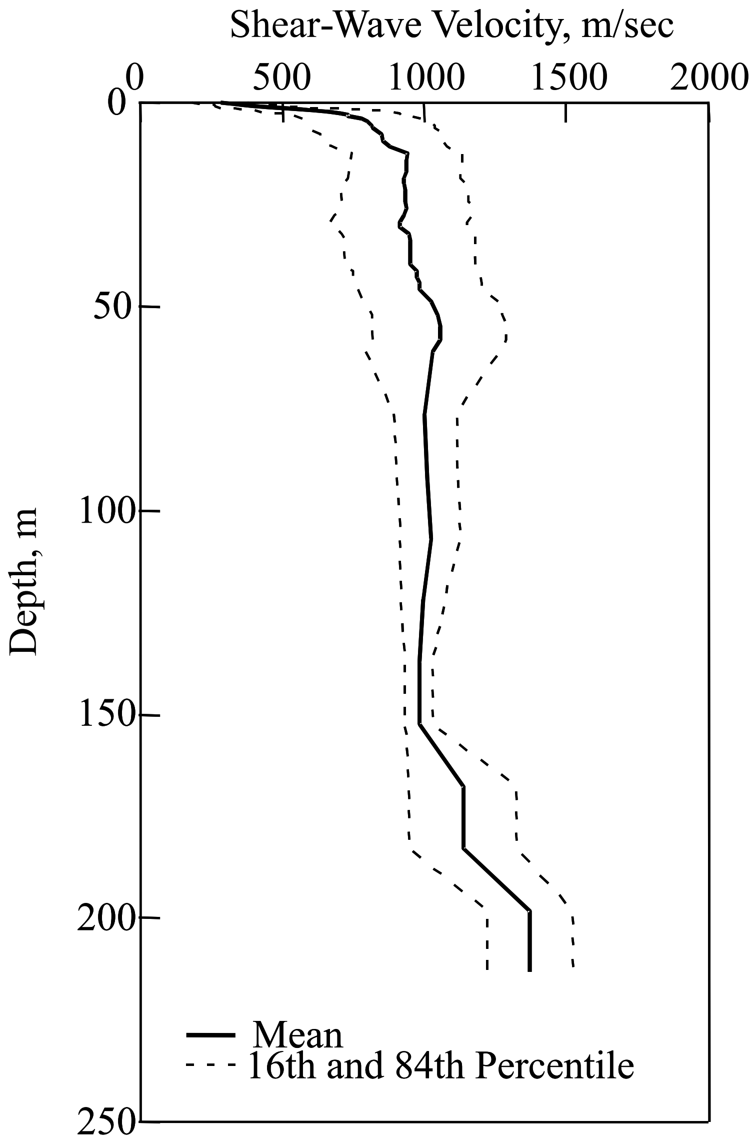

Farr Source
(5kg)
Near Source
(5kg)
Receivers
2 m
1 2 11 12
Vs., m/sec
0 2000
Depth, m
0
10
20
30
40
Depth, m
0
5
10
15
0 5 10 15 20 25 30 35 40 45 50 55
Location, m
250
400
550
700

SASW Method for Deep Profiling

Low-frequency vibroseis, 64,000 lb-heavy Liquidator



Typical time histories of a vibroseis source



■ Applications of the SASW Method

Applications of the SASW Method

Pavement Systems

- NDE of asphalt pavements
- Modulus and thickness of pavement layer, subgrade and grade

Concrete Structures

- Structural Integrity test of
  - Tunnel Concrete Lining
  - Concrete Bridge Deck
  - Retaining Wall

Geotechnical Sites

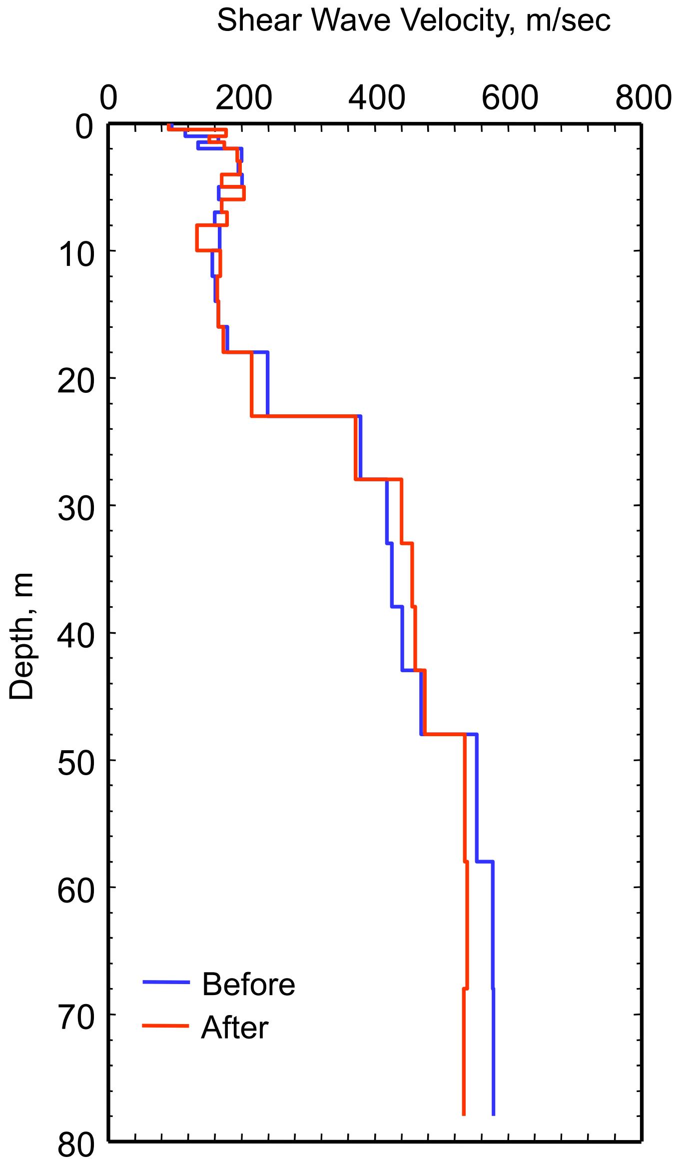
- Evaluation of Compaction Quality
- Site Investigation of
  - MSW Landfill
  - Road bed or Railroad bed
- Evaluation of Vacuum Consolidation
- Shear-Wave Velocity Profile for Seismic Analysis

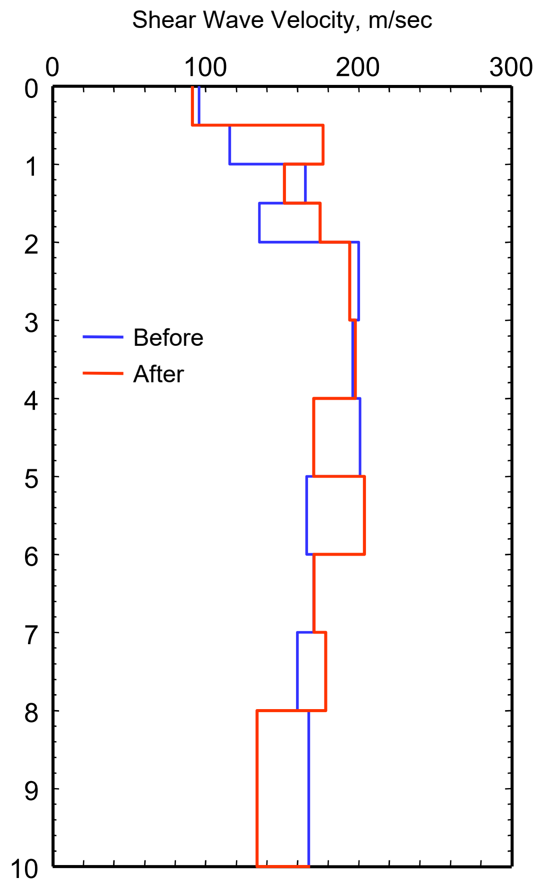
Quality Assurance of Compaction

- **Compaction by Hydraulic Hammer:**

  Runway of Inchon International Airport

• Comparison of Shear-Wave Velocity before and after Compaction



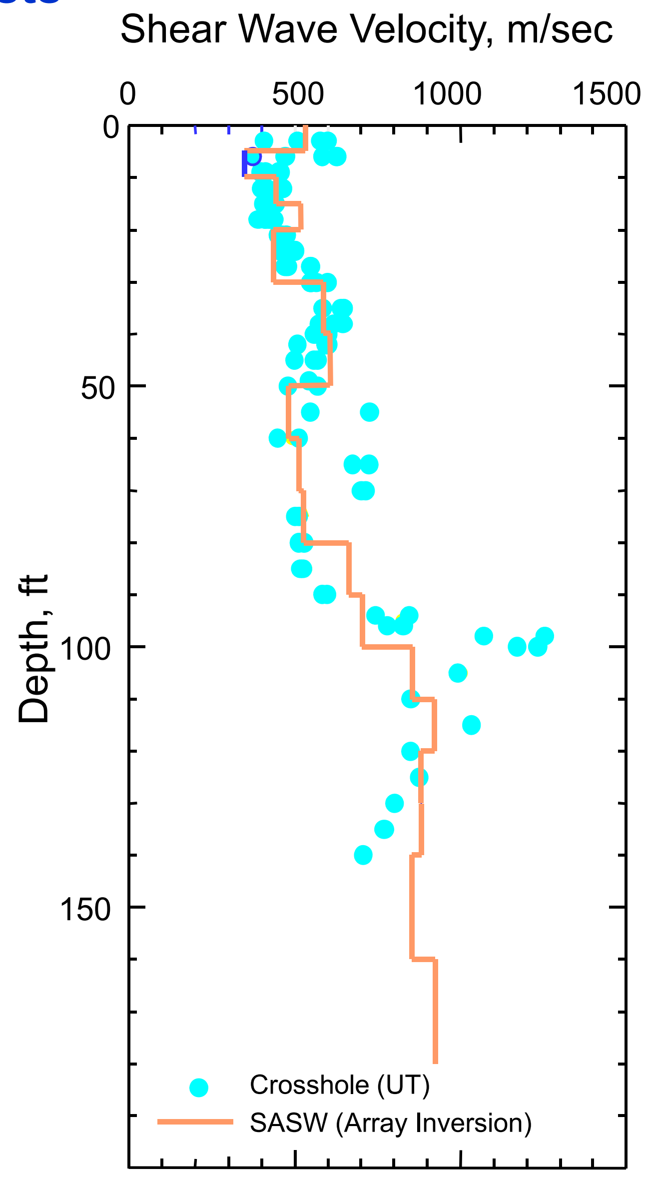


Site Investigation at Man-Made Island

- **Stiffness Profiling of Engineering Fill**

  Treasure Island in San Francisco

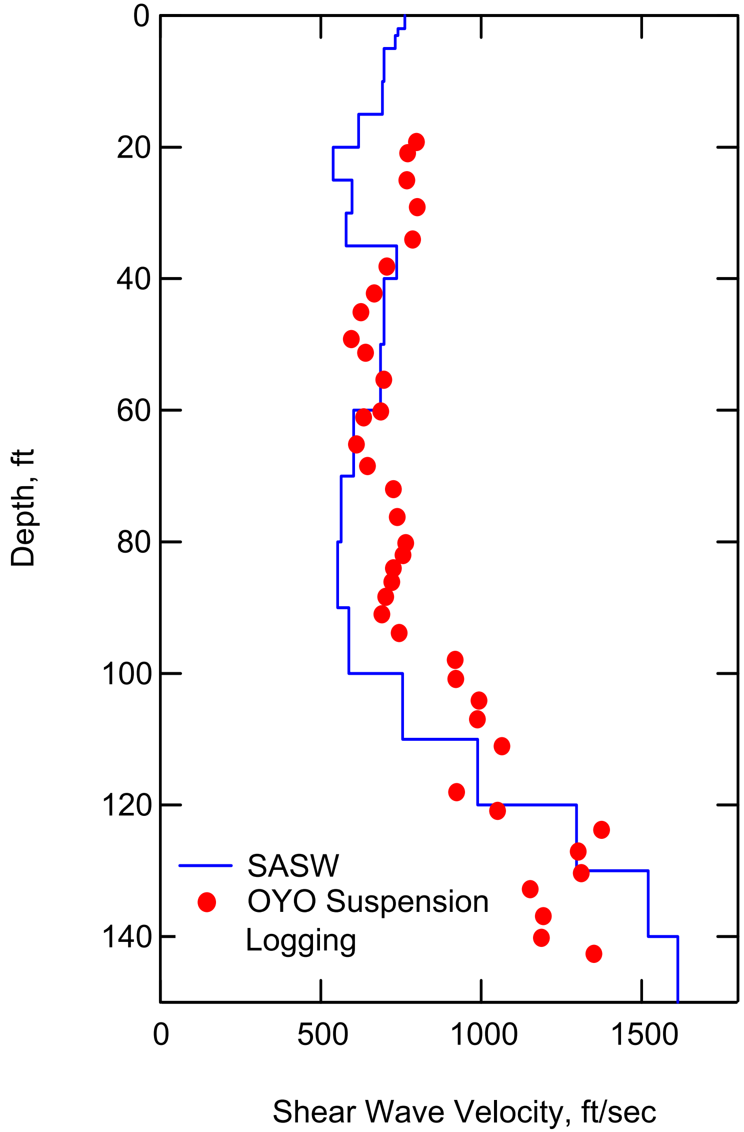
- **Comparison of Shear-Wave Velocity Profiles from SASW and Crosshole Tests**



Site Investigation of MSW Landfill Site

- **Vs Profiling of OII Landfill at LA, USA:**

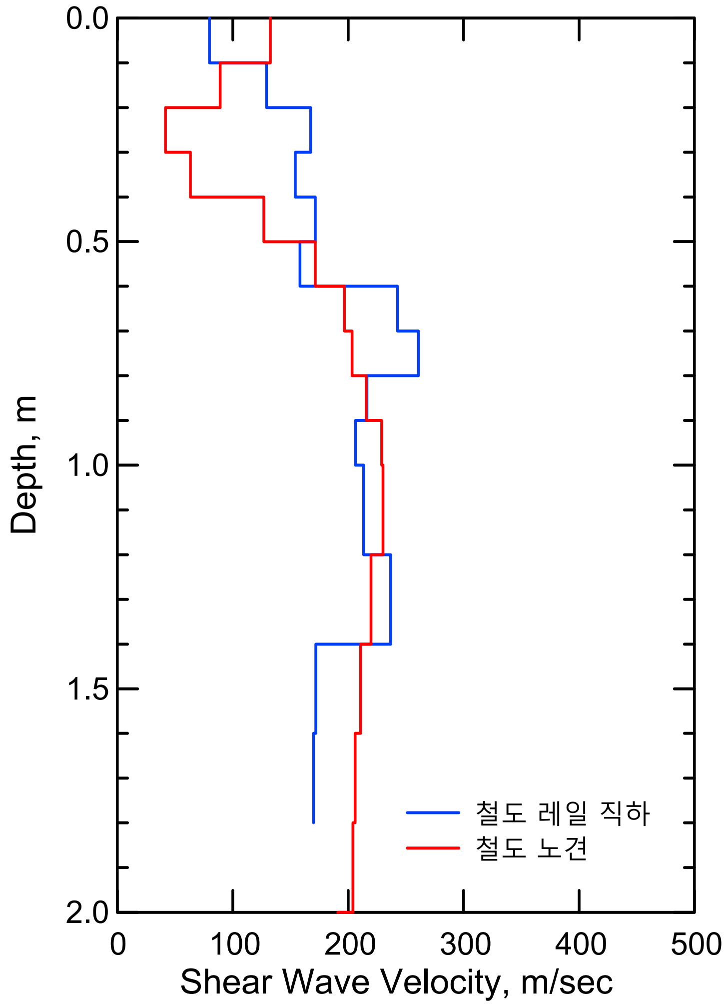
  Comparison between SASW Results and Results of OYO Suspension Logging



Stiffness Profiling of Ballast and Railroad Bed

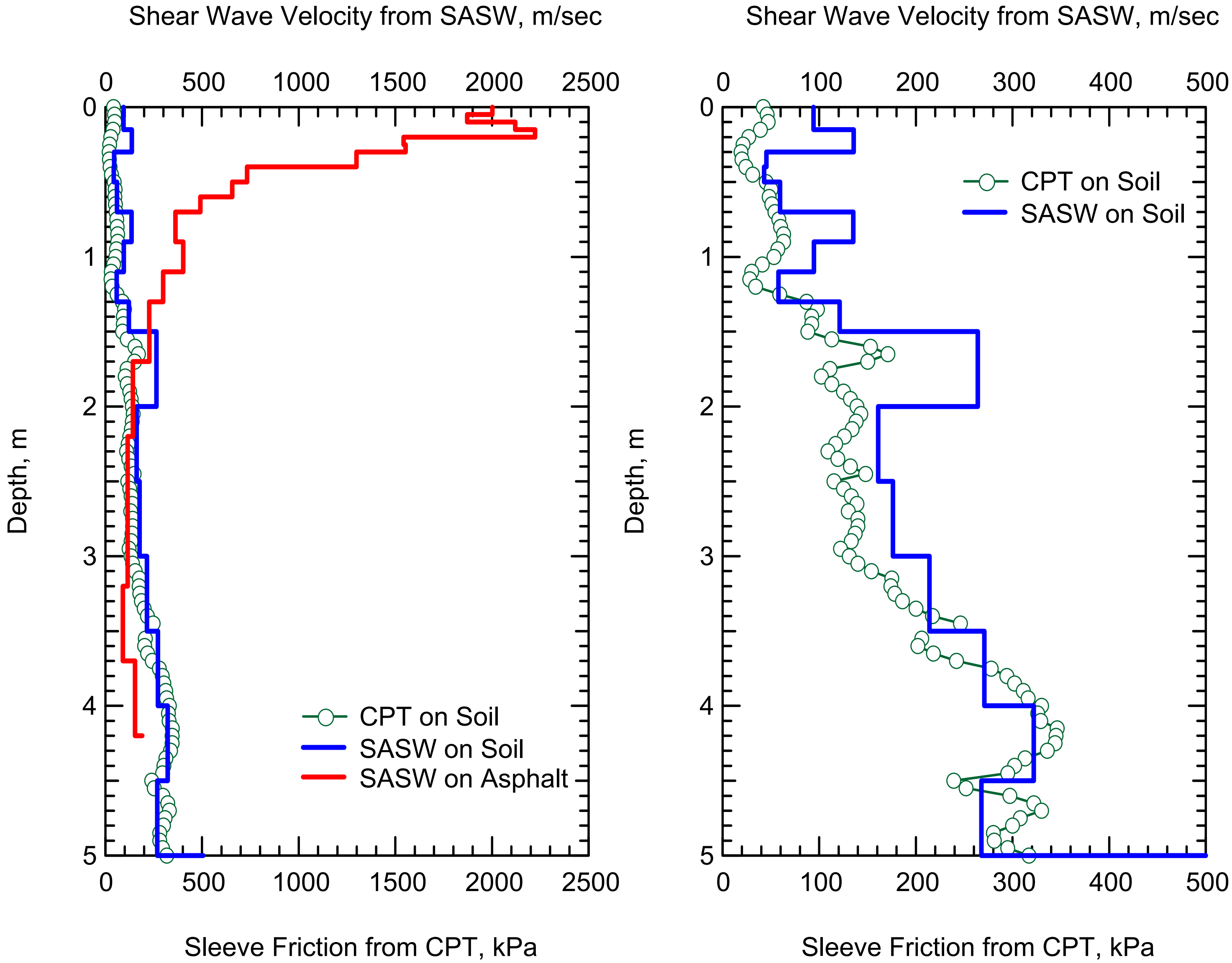
- **Vs Profiling of Ballast and Railroad Bed to Investigate Mud Pumping**

- **Shear-Wave Velocity Profiles from Inversion Analyses**



■ V_s Profiling of Asphalt Pavement System

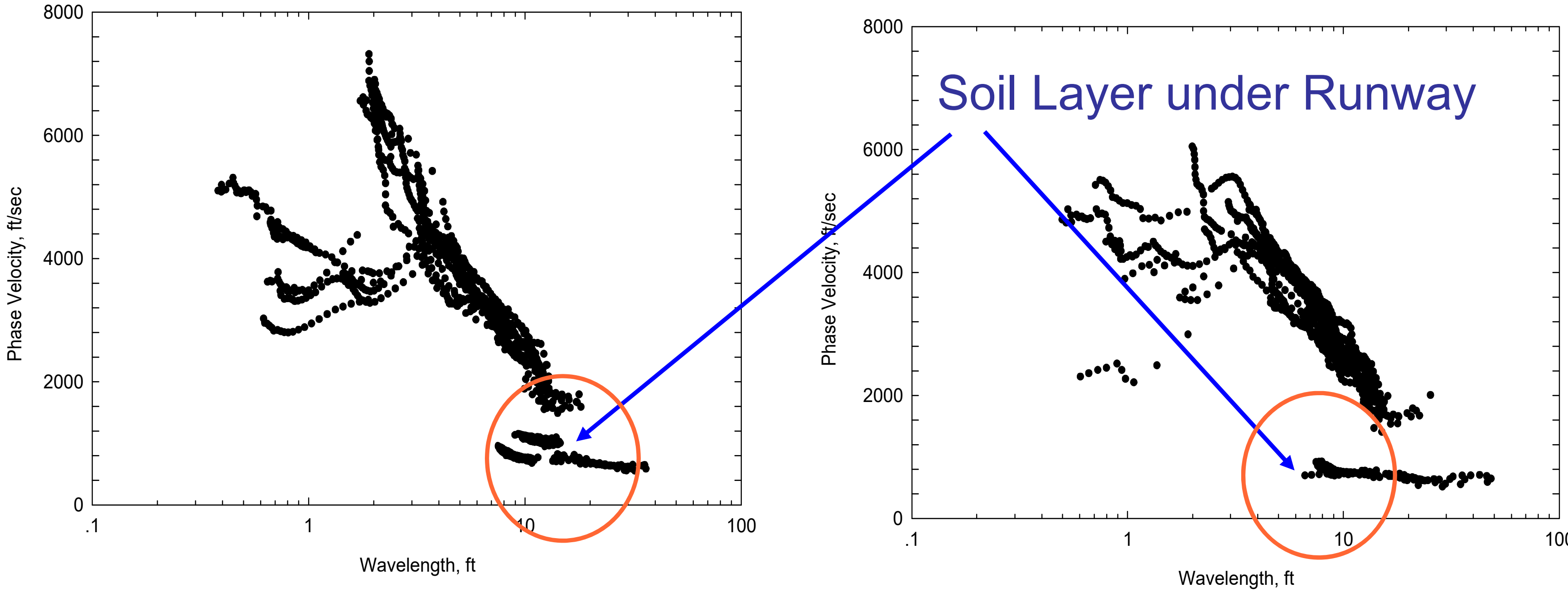
- V_s Profiles from SASW Tests



Comparison between Results of SASW Tests and CPT

Stiffness Evaluation of Soil Layers under Airport Runway

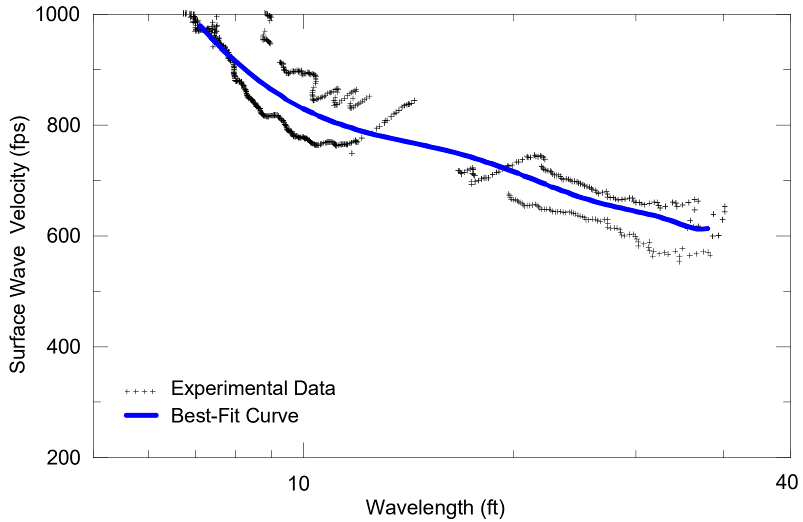
- JFK Airport, New York



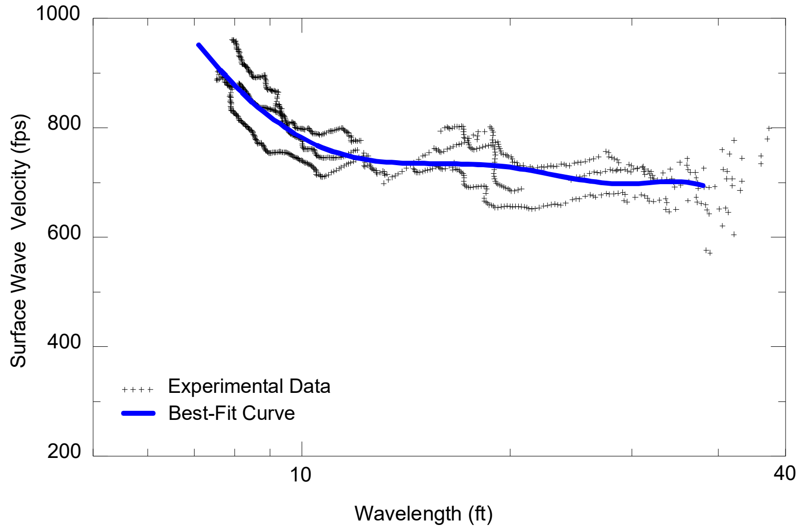
Before Tunneling

After Tunneling

- Experimental Dispersion Curve for Runway of JFK Airport (Expanded for Long Wavelengths)



Before Tunneling



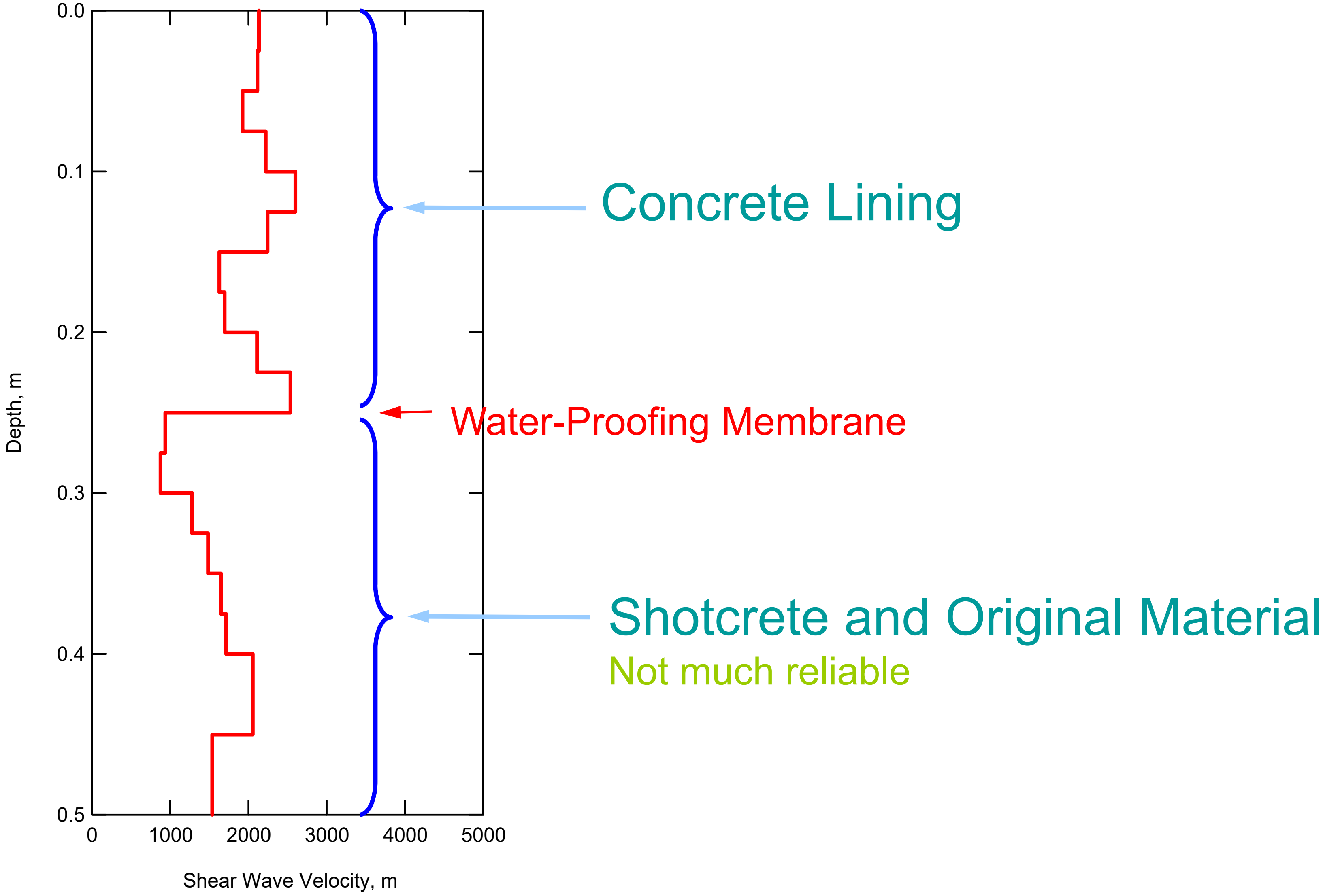
After Tunneling

■ Investigation for Tunnel Concrete Lining (1)

- **NDE for Tunnel Concrete Lining:**

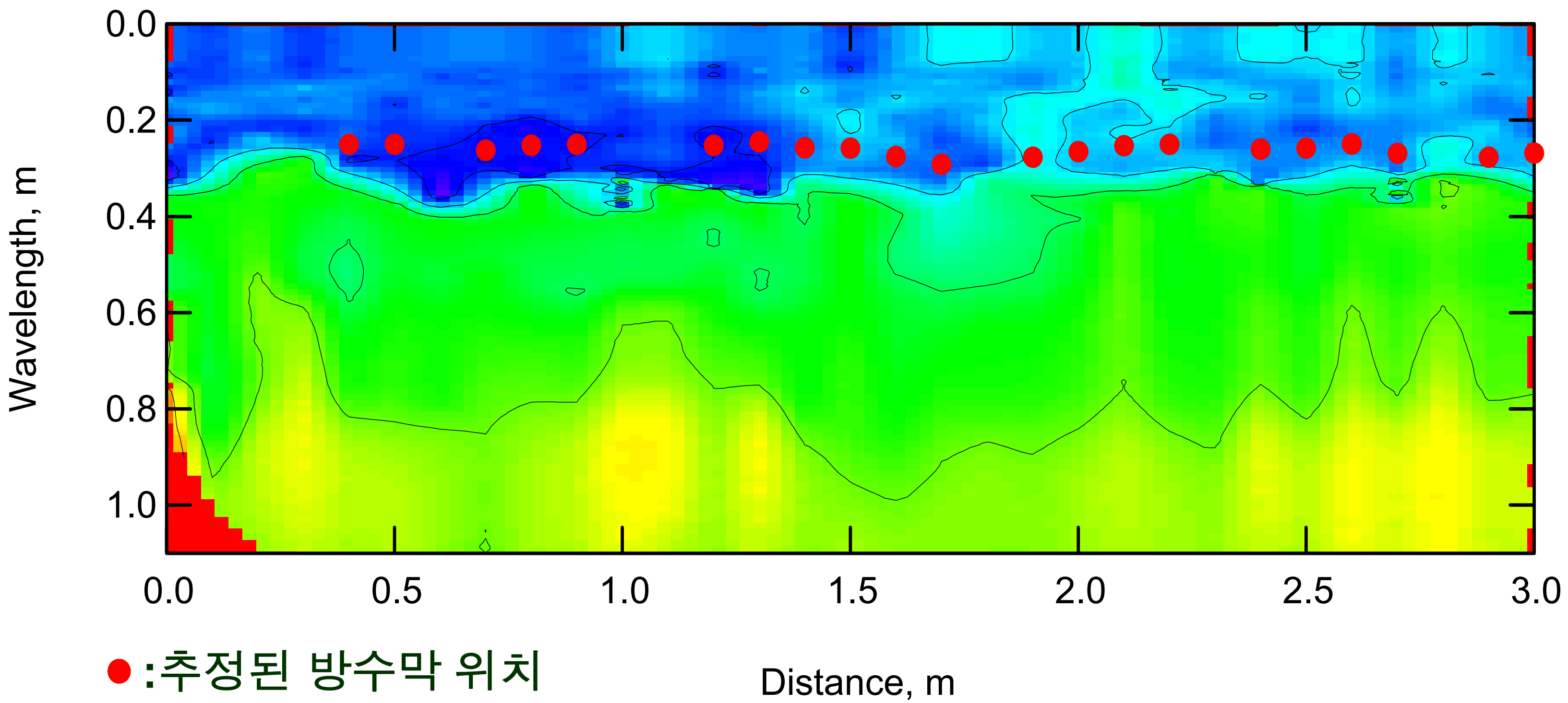
Road Tunnel

- **1-D Shear Wave Velocity Profile**

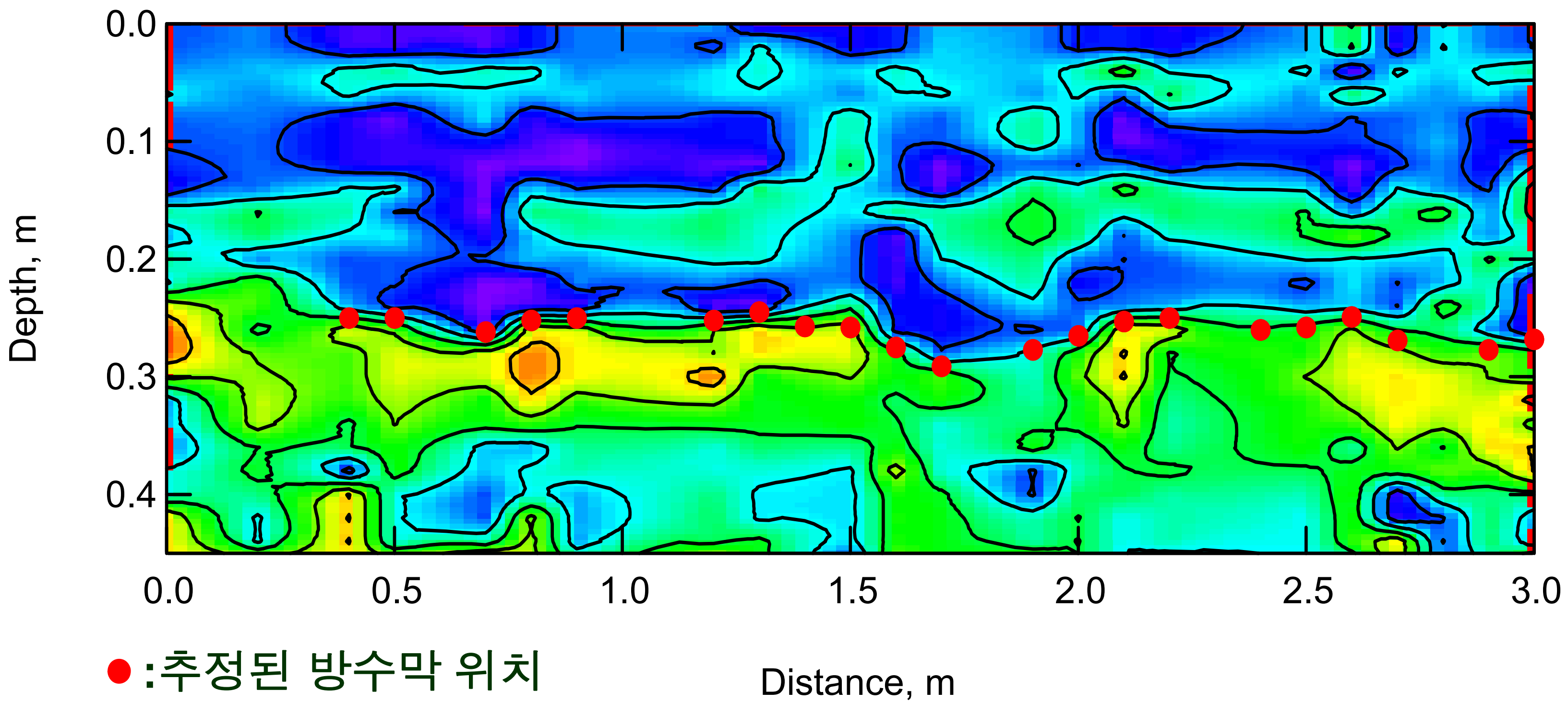


• 2-D Stiffness Profile

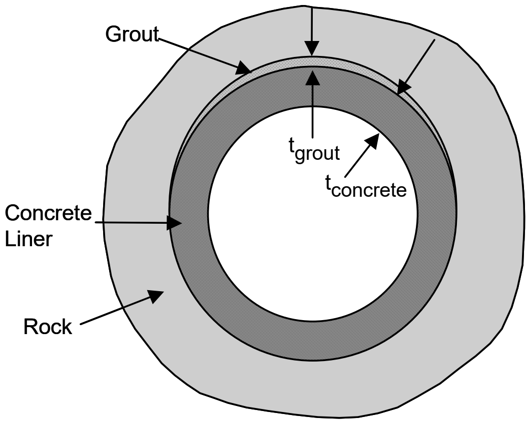
1-D Phase Velocity profile in Wavelength-Distance Domain



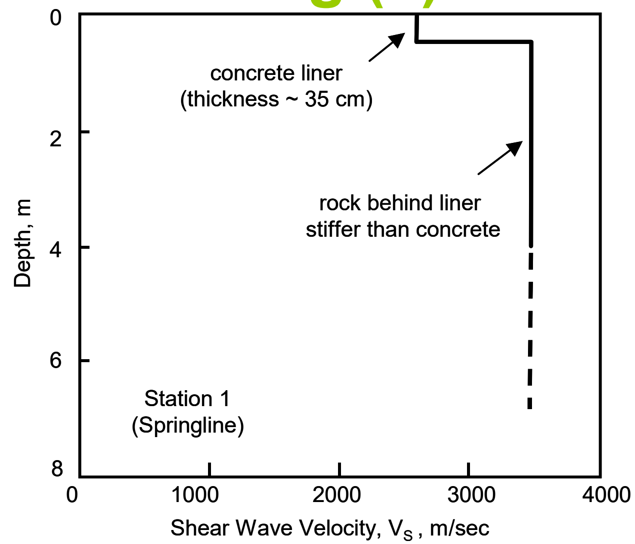
2-D Shear-Wave Velocity Profile of Tunnel Concrete Lining in Depth-Distance Domain



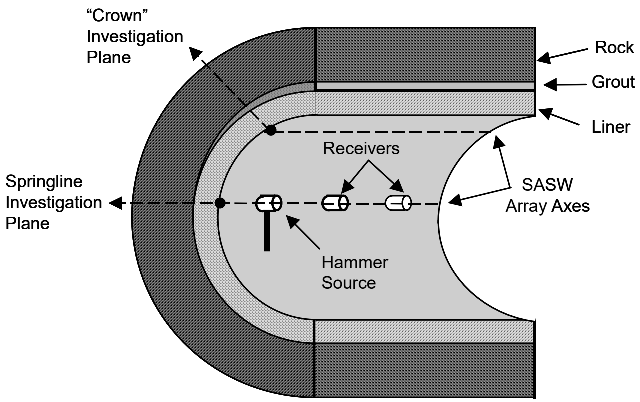
Investigation for Tunnel Concrete Lining (2)



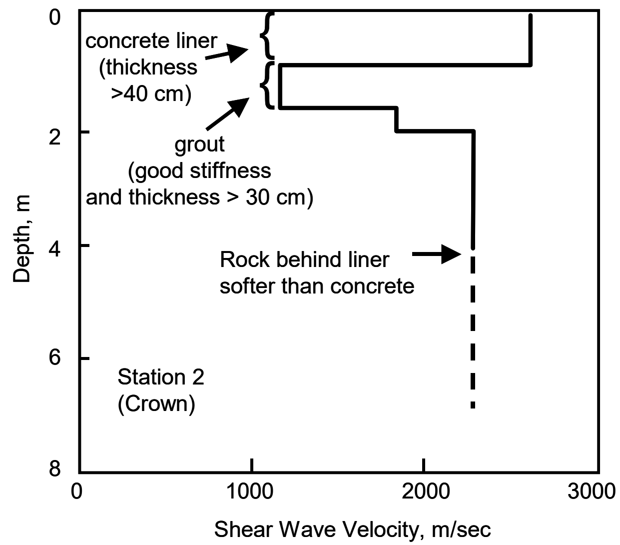
(a) Generalized Tunnel Cross Section



(a) Interpreted V_s profile at a springline station



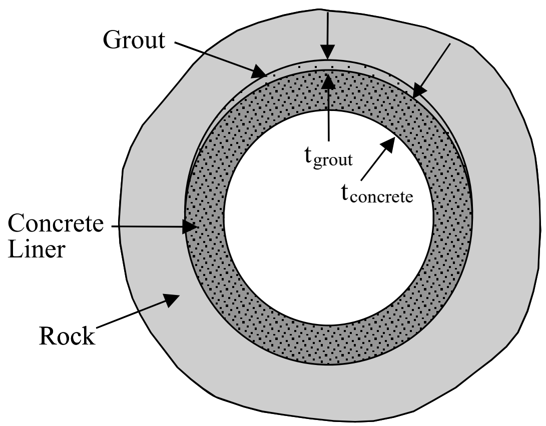
(b) SASW Testing Arrangement and Planes of Investigation



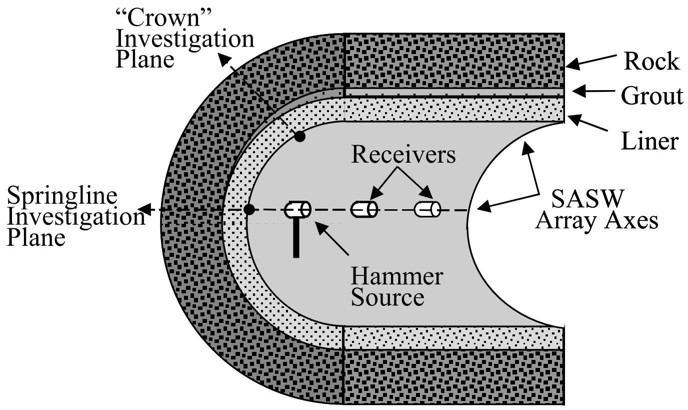
(b) Interpreted V_s profile at a "crown" station

SASW testing performed inside a concrete-lined tunnel (from Stokoe and Santamarina, 2000)

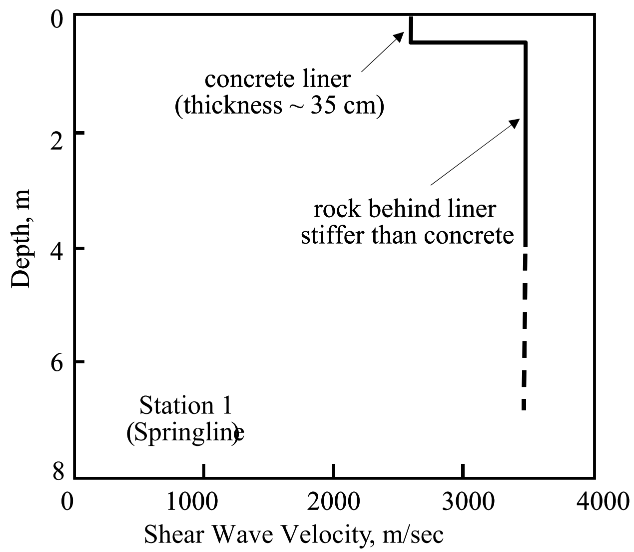
Examples of V_s profiles measured inside a concrete-lined tunnel (from Stoke and Santamarina, 2000)



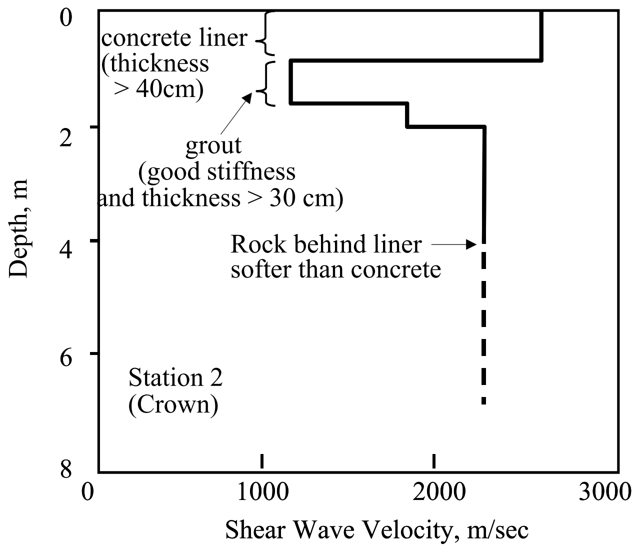
(a) Generalized Tunnel Cross Section



(b) SASW Testing Arrangement and Planes of Investigation



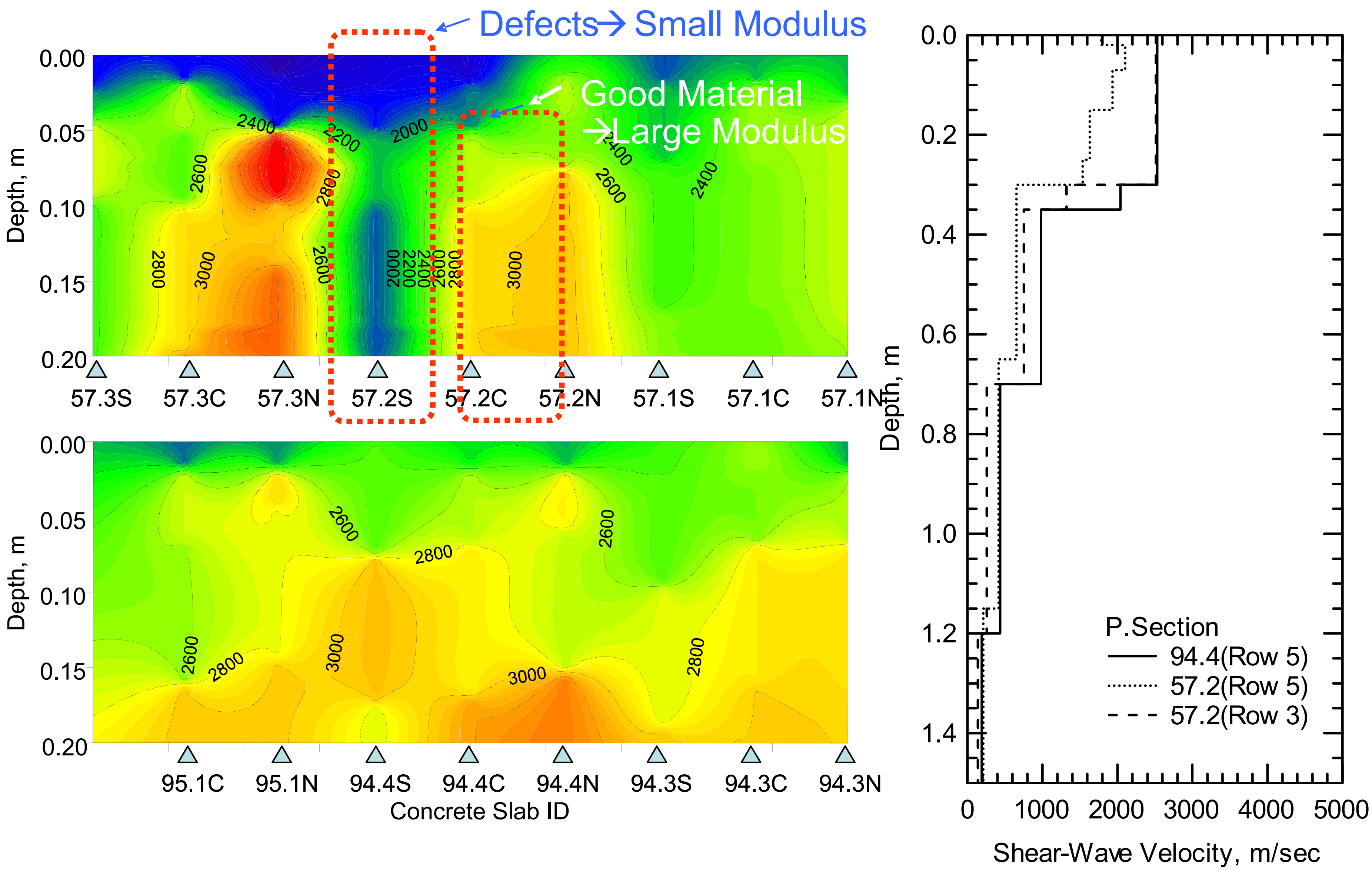
(b) Interpreted V_s profile at a springline station



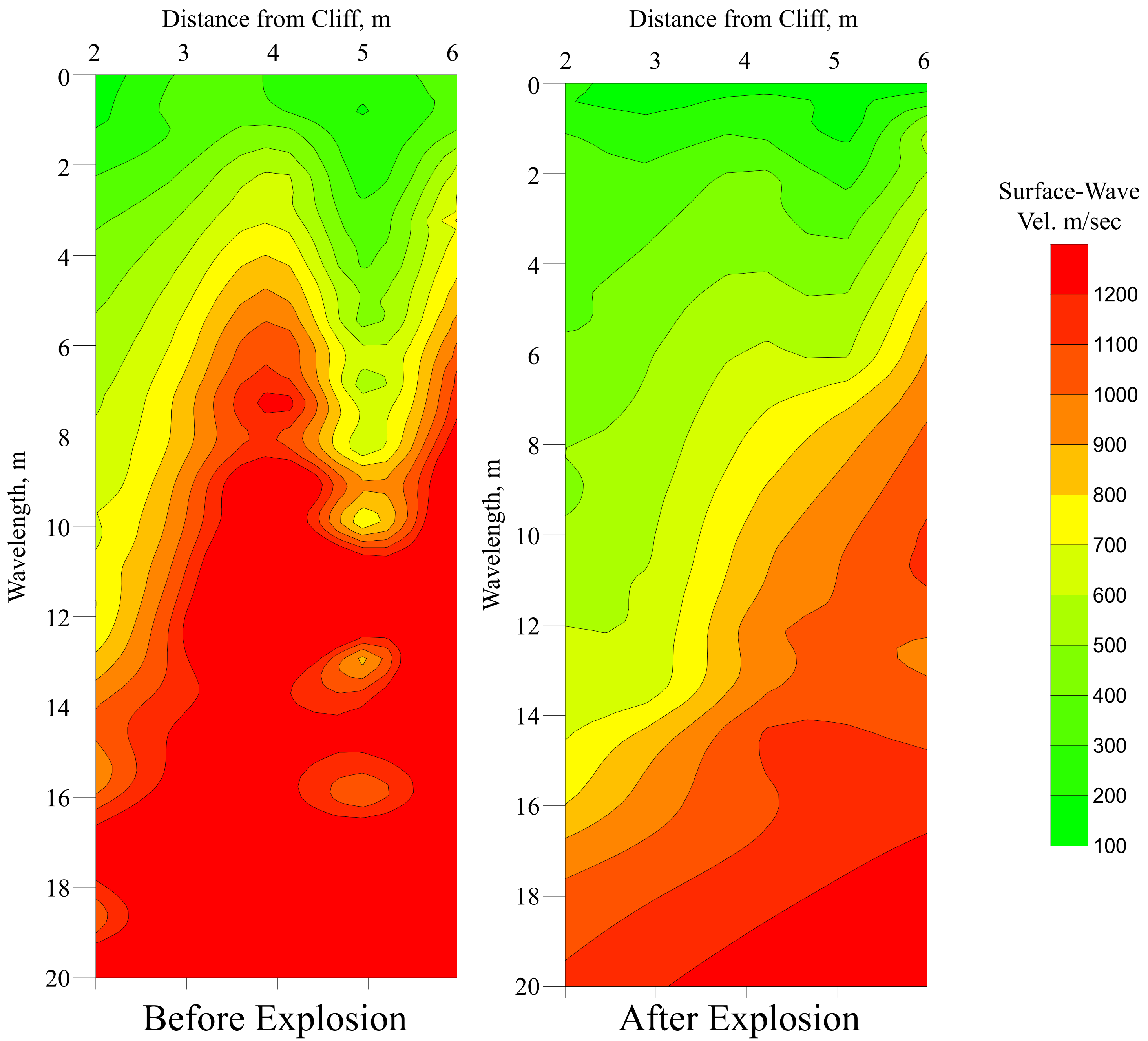
(b) Interpreted V_s profile at a "crown" station

Examples of V_s profiles measured inside a concrete-lined tunnel (from Stoke and Santamarina, 2000)

Investigation of Surface Cracks in Concrete Runway



■ Investigation of Damanaged Area after Explosion


Distance from Cliff, m
2
3
4
5
6
0
2
4
6
8
10
12
14
16
18
20
Wavelength, m
Before Explosion
Distance from Cliff, m
2
3
4
5
6
0
2
4
6
8
10
12
14
16
18
20
Wavelength, m
After Explosion
Surface-Wave
Vel. m/sec
1200
1100
1000
900
800
700
600
500
400
300
200
100

Thank you for your attention!

감사합니다.