COURSE DESCRIPTION

Since its first introduction in the late 1990s, the multichannel analysis of surface waves (MASW) method has been utilized by an increasing number of practitioners for a growing array of geotechnical projects, and further researched by many investigators worldwide. The MASW method provides one of the most critically important geotechnical parameters—stiffness of ground materials. It provides this information in terms of seismic shear-wave velocity (Vs) distribution in both vertical and horizontal directions. From an elastic theory viewpoint, shear-wave velocity (Vs) is the most powerful indicator of a material's stiffness.

This course covers the basics of seismic surface waves, data acquisition, and data processing in very layman's terms. The course will cover the fundamentals in such a way that participants can, upon its completion, engage in common applications such as seismic site characterization (Vs-30m) and mapping soil/bedrock shear-wave velocity (Vs) cross sections. It will also briefly demonstrate actual data acquisition in the field by using a typical set of equipment (if this option is selected). It will demonstrate how to process surface-wave data, and each participant will be guided step-by-step in processing actual field data sets, by using a trial version of proprietary software distributed and installed on a laptop computer. It will also cover advanced techniques and recent developments to ensure successful handling of more challenging projects.

The course includes time for project consultation and open discussion so that each participant can bring his or her own topics, data sets, and potential projects to openly consult during the class.

This full-day course will consist of two major sessions scheduled in the morning and afternoon respectively. The morning portion ("Part I - Fundamentals") covers most of the fundamentals in theory and field operations, and the afternoon portion ("Part II - Plus") provides hands-on guidance on how to process field data sets, and also covers more advanced topics aimed at tackling more challenging projects.

All geotechnical engineers and researchers dealing with stiffness of ground and pavement can benefit from attending this course and learning about this state-of-the-art seismic technique.

The Primary Objectives of the course are:

- to grasp basic concepts of seismic surface waves,
- to understand the overall field procedure for optimal data acquisition,
- to provide first-hand experience in processing field data sets to generate two-dimensional (2-D) shear-wave velocity (V) cross sections as well as 1-D profiles,
- to recognize typical applications of MASW, and
- to be fully flexible in data acquisition and processing so that one can handle challenging situations more successfully.

TENTATIVE SCHEDULE

Part I – Fundamentals

(8:00 am - 12:00 pm)

Duration (hr)

1. **What is MASW?** 0.5-1.0
2. **Field Operation** 0.5-1.0
3. **Data Processing** 0.5-1.0
4. **Passive MASW** 0.5
5. **Typical Applications** 0.5-1.0
6. **Outdoor Data Acquisition*** 1.0

Lunch (12:00 - 1:00 pm)

Part II – Plus

(1:00 pm - 5:00 pm)

Duration (hr)

1. **Processing Field Data Sets** (1D Profile and 2D Cross Section)** 1.5-2.0
2. **Special Processing (Back-Scattering and Common-Offset Analyses)** ... 0.5-1.0
3. **Advanced Topics (Dispersion, Inversion, Modeling, etc.)** 0.5-1.0
4. **Project Consultation / Open Discussion** 1.0-1.5

**optional depending on the local request and condition*
***by using the ParkSEIS (v. 3.0) software with a temporary license*

INSTRUCTOR BIO

Dr. Choon Park

Founder & Principal Geophysicist
Park Seismic LLC
Shelton, Connecticut, USA
Email: choon@parkseismic.com, Tel: 347-860-1223

Dr. Choon Park is lead author of the MASW technique, published in *GEOPHYSICS* (1999) while he was at the Kansas Geological Survey (KGS) (1988-2006). Since then, Dr. Park has published more than one hundred papers on MASW and related topics. He is currently founder and principal geophysicist at Park Seismic LLC, a firm that provides R&D and analytic services for near-surface geotechnical applications. During the last two decades, he has been engaging with relevant engineering communities to help apply the near-surface seismic method to an increasingly diverse array of geotechnical projects. He has taught MASW courses at more than twenty geophysical and geotechnical conferences.

Dr. Park received his Ph.D. from the University of Kansas (KU) (1995). His dissertation developed a high-frequency near-surface seismic investigation method that delivers a few hundred seismic impacts in a coded mode to increase the signal-to-noise (SN) ratio of reflection waves. In parallel to this, Dr. Park also performed research on low-frequency near-surface seismic investigation by utilizing surface waves (commonly known as ground roll), which ultimately led to the development of the MASW method. He is the author of the first MASW data-processing software, SurfSeis, and coauthor of the seismic reflection software, WinSeis and Eavesdropper, both of which were developed at KGS. Dr. Park received his master's (MS) degree from Ohio University (1988) with research in the migration of high-frequency reflection data for near-surface investigation.

HANDOUT SUMMARY

Fundamentals of MASW will be covered in the following topical areas:

- Multichannel Seismic Survey
- Data Acquisition (Active and Passive)
- Data Processing (Dispersion and Inversion)
- Typical Applications
- Practice of Data Processing
- Outdoor Demonstration of Data Acquisition
- In-Class Data Processing with Acquired Data

In addition, in-depth coverage of advanced topics will be included in the following categories:

Dispersion Imaging (Complications and Causes)

- Why the fundamental mode (M0) is not necessarily the only dominant mode
- When higher modes (M1, M2, etc.) are dominant
- What determines modal energy partitioning
- How multiple modes get mixed together
- Bedrock depth and dispersion images
- Complications from inverse velocity models
- Understanding fundamentals of dispersion imaging
- Computational artifacts from dispersion imaging
- How to extract dispersion curves from complicated image patterns
- Multi-source offset survey and dispersion images
- Methods to process passive data
- Common pitfalls

Inversion Analysis

- Different Approaches (Pros and Cons):
    - ✓ Traditional fundamental-mode (M0) inversion
    - ✓ Multi-mode inversion (M0, M1, M2, etc.)
    - ✓ Mixed-mode (or apparent mode) inversion
    - ✓ Dispersion image (or phase-velocity spectrum) inversion
    - ✓ Full-waveform inversion
    - ✓ Simple in-field inversion
    - ✓ Inversion of pavement data
- Searching Optimization
    - ✓ Deterministic vs. stochastic approaches
    - ✓ How to optimize the initial velocity model
- Inversion Results
    - ✓ What they represent
    - ✓ What to believe and what not to believe
- Common Pitfalls

Data Acquisition

- How to determine the critical parameters of source offset (X1), receiver spacing (dx), number of channels (Nch), and survey interval (dSR) for 2-D mapping
- How to choose the optimum receiver

  - ✓ Are low-frequency phones (e.g., 4.5 Hz) really critical?
  - ✓ Can higher-frequency phones (e.g., 14-Hz, 40-Hz, etc.) be used?
- How to choose the optimum source
  - ✓ Sledge hammer (10-lb, 20-lb, etc.) or weight-drop?
- Passive Survey
  - ✓ When and how?
  - ✓ How much gain to expect
- Multi-source offset survey: why and when
- How to handle different bedrock depths
  - ✓ Shallow (e.g., ≤ 2m), moderate (e.g., ≤ 10 m), and deep (e.g., > 10 m)
- Surveying over pavement
  - ✓ Shadow zone and investigation depth
  - ✓ Differences in acquisition and processing
- Common Pitfalls

Special Processing

- Back-scattering Analysis of Surface Waves
  - ✓ How it works
  - ✓ Applications
- Common-offset display
  - ✓ What it represents
  - ✓ What different offsets and frequency bands represent

Common Applications

- Soil/Bedrock Mapping
  - ✓ Wind-turbine site surveys and seismic site classification (1-D survey)
  - ✓ Cross-section geotechnical characterization (2-D survey)
  - ✓ Multiple 2-D surveys and depth slicing (3-D survey)
  - ✓ Evaluation of overburden velocities (S- and P-wave velocities; Vs and Vp)
  - ✓ Evaluation of bedrock velocities (Vs and Vp)
- Outcrop Surveys (with Little or No Soil)
  - ✓ Differences in data acquisition and analysis
- Anomaly Detection
  - ✓ Void and loose zone mapping by velocity (Vs) analysis
  - ✓ Use of back-scattering and common-offset analyses
- Compaction Evaluation by MASW Surveys (CEMS)
  - ✓ Application to FDR (Full-Depth Reclamation) pavement construction
  - ✓ Application to DDC (Deep Dynamic Compaction)

Case Studies

- Actual projects previously performed
  - ✓ Wind-turbine site investigation and seismic site classification (Vs-30m) (1-D Vs profiling)
  - ✓ Overburden/bedrock investigation (2-D Vs cross section)
  - ✓ Anomaly detection (void/sinkhole investigation by surface-wave scattering)