Course Title: Multichannel Analysis of Surface Waves (MASW)
Format: Two-Half-Day Course (PM Session in Day 1 and AM Session in Day 2)
Date and Location: April 6, 2016 (location to be announced later)
Instructor: Dr. Choon Park, Park Seismic LLC (MASW.com) Shelton, Connecticut, USA
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Lecture Schedule

time

1. **What is MASW? ..... 09:30 - 11:00**
   a. Surface wave propagation and MASW theory
   b. Overall procedure of MASW

Coffee Break ..... 11:00 - 11:15

2. **Field Survey for Data Acquisition ..... 11:15 - 12:00**
   a. Data acquisition equipment
   b. Key data acquisition parameters

Lunch Break ..... 12:00 - 13:00

Data Analysis ..... 13:00 - 14:00
   c. Preprocessing – Source/receiver (SR) setup
   d. Dispersion and inversion analyses

3. **Applications ..... 14:00 - 15:00**
   a. Typical applications
   b. Special applications

Coffee Break ..... 15:00 - 15:15

4. **Data Processing Tutorial ..... 15:15 - 17:00**
   a. Installation of MASW software (*ParkSEIS*)*
   b. Overview of the software
   c. Data processing with field data sets

**** A FREE copy of MASW software (ParkSEIS) with a 3-month license will be distributed to all participants.***

Instructor's BIO

Dr. Choon Park is lead author of the MASW technique published in *GEOPHYSICS* in 1999. He founded Park Seismic LLC in 2008, where he is currently working as the principal geophysicist. Since the late 1990s, Dr. Park has been promoting the MASW technique among relevant engineering and science communities by providing education at professional conferences.

Dr. Park received his Ph.D. from the University of Kansas (KU) in 1995, and then continued his career as a scientist at the Kansas Geological Survey (KGS), a research institute based at KU. Dr. Park has published more than a hundred papers on MASW and related techniques. He is also the author of the first MASW data-processing software, SurfSeis, and coauthored the seismic reflection software, WinSeis and its predecessor Eavesdropper. He received his master's (MS) degree from Ohio University (1988) and graduated from Seoul National University (1983) in Seoul, South Korea, with a BS in physics and science education.

Course Description

The multichannel analysis of surface waves (MASW) method provides one of the most critically important geotechnical and structural parameters—stiffness of ground and pavement materials. It gives 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. Basics on surface waves, data acquisition, and data processing are covered in very plain terms. The course will cover enough fundamentals so that you can start those common applications such as seismic site characterization for Vs-30m classification and mapping soil/bedrock shear-wave velocity (Vs) cross sections. It will also cover advanced techniques and recent developments to ensure successful handling of challenging projects such as anomaly detection and noisy-environment surveys. The course will present and discuss several survey cases previously executed.

This full-day course will consist of two major parts; the first part covering most of the fundamentals in theory and field operations, and the second part dealing with those advanced topics recently developed that can improve the overall effectiveness of the MASW approach and also help work successfully with more challenging projects.

The course also includes a data-processing practice session that will use a pre-distributed software that comes with a 3-month license (for non-commercial use only). The afternoon part of this course will start with an outdoor field survey nearby the classroom. It will demonstrate how to deploy survey instruments. It will also acquire some field data to process for a 2-D velocity (Vs) cross section that will take place afterward in the classroom.

All geotechnical engineers as well as geologists and geophysicists should attend the course to learn about this state-of-the-art seismic technique. Objectives of the course are

- to grasp basic concepts of seismic surface waves and understand the overall field procedure,
- to learn about how to produce 1-D and 2-D shear-wave velocity (V) profiles,
- to recognize typical applications with MASW and be fully flexible in data acquisition and processing so that one can handle challenging situations more successfully.

Course Contents

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
- Data Processing — In-class Demonstration and Practice*
- Deployment of survey instruments
- Actual outdoor field survey

**A copy of MASW software (ParkSEIS) will be distributed to all participants that comes with a 3-month license (for non-commercial use only).*

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

Dispersion Imaging (Complications and Causes)

- Why 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 to each other
- Bedrock depth and dispersion image
- Complications from inverse velocity models
- Understanding fundamentals of dispersion imaging
- Computational artifacts from dispersion imaging
- How to extract dispersion curve from complicated image patterns
- Multi-source offset survey and dispersion image
- Passive imaging methods
- 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 initial model
- Inversion Results
  - ✓ What they represent
  - ✓ What to and not to believe
- Common Pitfalls

Data Acquisition

- How to determine those critical parameters of source offset (X1), receiver spacing (dx), number of channels (Nch), and survey interval (dSR) for 2-D mapping
- How to choose optimum receiver
  - ✓ Low-frequency phones (e.g., 4.5 Hz) really critical?
  - ✓ Higher-frequency phones (e.g., 14-Hz, 40-Hz, etc.) can be used?
- How to choose 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) cases
- Survey 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 Survey (Little or No Soil)
  - ✓ Differences in data acquisition and analysis
- Anomaly Detection
  - ✓ Void and loose zone mapping
  - ✓ 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)