

## Multiple Impact Surface Waves »

*Multiple Impact Surface Wave (MISW) investigations are used in QA or forensic investigation of subgrade, base and top asphalt/concrete pavement layers as well as for structures and tunnels.*



**Multiple Impact Surface Waves (MISW)** systems are designed to measure asphalt and concrete pavement surface layer (Single Layer software) thicknesses to within ~ 0.2 to 0.4 inches (~ 5 to 10 mm) when calibrated with limited cores. In addition, the MISW system can be used to measure surface wave velocity profiles vs. depth from which Young's (elastic) moduli and layer thicknesses are determined (Single Layer and Multiple Layer software options). The pavement layer thickness/moduli profile is used for mechanistic-empirical pavement design and rehabilitation studies. The MISW system can be used for Quality Assurance/Quality Control (QA/QC) purposes for each layer of a pavement system during construction to provide pavement system layer thickness, typically the surface pavement layer, and moduli data for pavement, base, and subgrade layers. In pavement rehabilitation projects, MISW can be used to measure asphalt/concrete thickness/moduli as well as the thickness/moduli of the underlying base, and subgrade layers of pavement systems.

**Features:**

- Surface pavement layer thickness can typically be determined to ~ 0.2 to 0.4 inches (~ 5 to 10 mm) along with Young's moduli (asphalt moduli is temperature corrected)
- Real-time waveform display and surface layer data processing while testing
- NDE 360 MISW systems are compact, durable, and easily transported allowing for multiple tests per day and field analysis of top layer results
- Freedom Data PC MISW system allows for field analysis of top layer results and more detailed field processing of data
- MISW offers improved accuracy vs. other surface wave methods for thickness/Young's Moduli profiles
- SeisNDT-SL Single Layer software (by Dr. Nils Ryden) for QA of thickness/moduli of pavement (asphalt/concrete), base (gravel, cement, or lime-treated roadbase materials), and subgrade layers during new construction
- SeisNDT-ML Multiple Layer software for forensic thickness/moduli determination of pavements and other layered systems (includes SeisNDT-SL for Single Layer Systems)

The MISW test method utilizes many of the same principles, equations, and data collection procedures as the SASW method (see SASW-S section). The differences between the two methods are predominantly in the data collection and processing where the MISW method is based on multichannel data processing techniques, developed for the Multichannel Analysis of Surface Waves (MASW) method. All of the data taken during MISW testing is analyzed together to create a dispersion image or phase velocity spectrum.

<b>» Applicable On:</b>
Asphalt
Base
Concrete
Rock
Subbase
Subgrade Soil
<b>» Test For:</b>
Layer Shear Moduli
Layer Poisson's Ratio
Layer Thickness
Layer Young's (Elastic) Moduli



Model	Advantages
MISW-SL	For thickness/moduli of surface pavement layer (asphalt/concrete) & moduli of base and subgrade materials as they are placed.
Options	Advantages
MISW-ML	Includes the theoretical modeling package for determination of thickness/moduli profiles of multiple and single layer systems.

# Multiple Impact Surface Waves »

## Method

In typical MISW tests, the generated surface waves are measured with an accelerometer fixed at zero offset. The testing proceeds by generating triggered hammer impacts out to a predetermined distance at fixed intervals of 2 to 8 inches (50 to 200 mm) and measuring the associated surface wave responses at the accelerometer. All recorded signals are then compiled to make an equivalent multi-channel record that can be transformed to a phase velocity spectrum similar to the Multichannel Analysis of Surface Waves (MASW) technique.

## Data Collection

The user-friendly MISW SeisNDT software was written by Dr. Nils Ryden. This software has been extensively tested at Olson Instruments' corporate office in Colorado and used for various projects. We do not outsource any tech support questions and, should you require software support, we welcome your questions and comments.

## Available Models

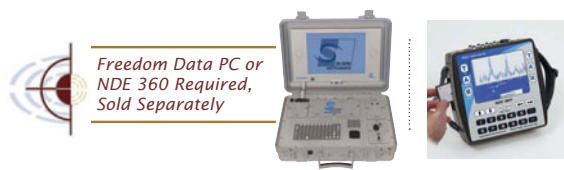
The Multiple Impact Surface Wave system is available in two different models which can be run from the Freedom Data PC or NDE 360 Platforms:

1. Multiple Impact Surface Waves – SL-1 (MISW-SL-1)
2. Multiple Impact Surface Waves – ML-1 (MISW-ML-1)

The **MISW-SL Model** is the the base model. This system includes the equipment and basic software required for performing MISW testing of single (top) layers, but does not include the modeling software for multiple layer systems.

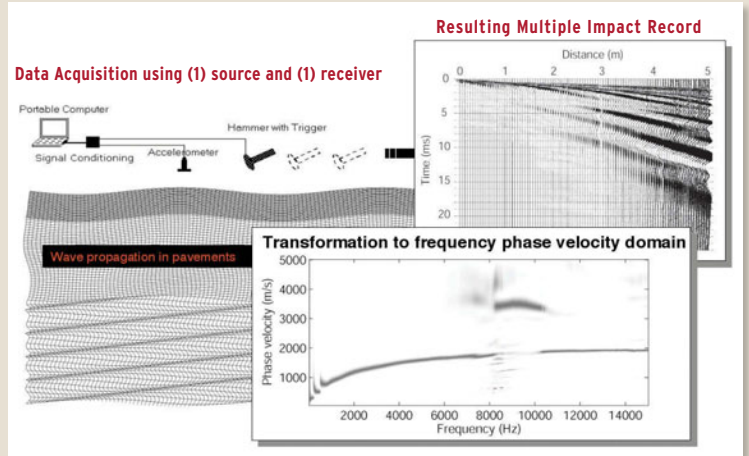
The **MISW-ML Model** includes the theoretical modeling software for multiple layer investigations of pavements (inversion), structures and tunnels making it the most complete MISW system available as it can also be used on single layer systems for QA of new pavement systems.

The MISW systems share many common attributes with the **Spectral Analysis of Surface Waves-S (SASW-S)**, system. For more information on the above mentioned test method, please refer to the individual section in this catalog.



## Data Example » 1

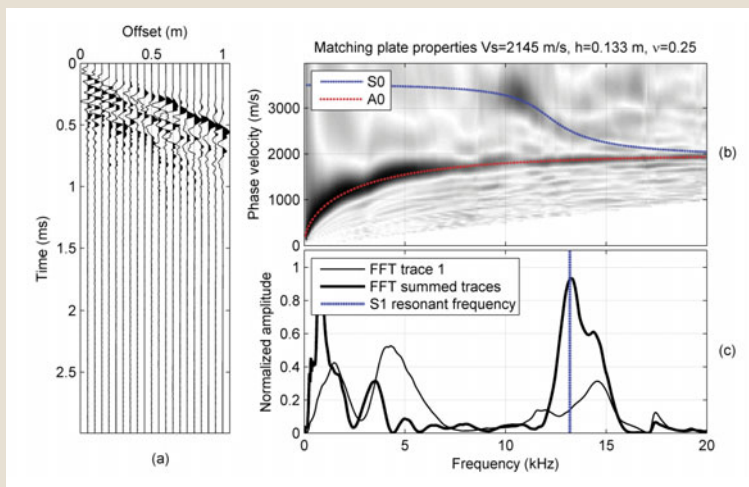
### Multiple Impact Surface Waves (MISW) approach to Seismic Pavement Testing



The MISW method is shown on the top left above with the resulting multiple impact surface wave data record in the top right. The time domain data is transformed to the frequency phase velocity domain as shown in the bottom center. At higher frequencies ( $+12,000$  Hz in the bottom center figure) and shorter wavelengths the symmetric (compressional - S0 is the fundamental mode) and anti-symmetric (flexural - A0 is the fundamental mode) wave propagation modes combine as the surface wave velocity in the top layer of a pavement system. At lower frequencies ( $< 2000$  Hz in the bottom center figure) the multiple wave propagation modes are analyzed together to determine the thickness/shear wave velocity/Young's moduli profiles of pavement, base and subgrade layers with the multiple layer theoretical modeling software to match the experimental frequency phase velocity domain data that is shown.

## Data Example » 2

### Multiple Impact Surface Waves (MISW) – Asphalt Results



This data (left side of plot) is typical for testing of the surface pavement layer, in this case asphalt. By assuming a free plate for the top asphalt (or concrete) pavement layer, one can simply match the S0 and A0 modes (see top right plot) and determine the S1 mode (impact echo thickness resonance frequency - see blue vertical cursor line in bottom right plot) to get the thickness (h), shear wave velocity ( $V_s$ ) and Poisson's ratio properties for the surface pavement layer (shown in the top right plot).