Surface Wave Methods for Near-Surface Site Characterization

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Within the last 15 or 20 years, there has been a rapid increase in the value of including the shear wave velocity profiles within building codes for determining and assigning an official site classification level to an area from a seismic or geotechnical engineering perspective. A variety of *in-situ* testing methods for determining the shear wave velocity profiles and material damping ratios within the all-important near-surface region of a given site has been developed and reported on in the literature. One of the more powerful and effective measurement techniques recently examined is the use of surface wave testing methods. Surface wave methods (SWMs) utilize transmitted Rayleigh- or Love-type surface waves as signal waves and thus have the advantages of possessing very high signal-to-noise ratios, are non-destructive or non-invasive and are also relatively accurate and simple to implement.

This book, *Surface Wave Methods for Near-Surface Site Characterization*, seeks to compile all of the important, yet disparate and seemingly uncoordinated, recent literature and experience in the use of SWMs for near-surface site characterization under one cover. Specifically it is the authors' stated goal of the book that it "provides a comprehensive, consistent, and clear description of each aspect of the (SWM) test in addition to guidelines for correctly performing and interpreting the results of this geophysical techniques.". This challenging objective has certainly been achieved and this book represents an excellent consolidation and formalization of this comparatively new and important subject area.

The first chapter of the book contains a general overview and introduction to the process of surface wave testing methods along with several sample applications. The general processes of surface wave testing, including the methods major phases of data acquisition, data signal processing and the final step commonly termed inversion, are all introduced and explained. Chapter 1 is therefore a summary chapter that lays down a good foundation for the greater detailed treatment of the theories and testing aspects provided in the rest of the book.

Chapter 2 is devoted to the theory and underlying physics of linear "wave propagation in a vertically heterogeneous half-space" that includes both elastic continua (for surface wave velocity determination) and viscoelastic continua (for examination of both velocity and damping characteristics of the site's near-surface region). As Chapter 1 was an introduction to surface wave testing methods, this second chapter lays the groundwork for the basic wave propagation theory that is the scientific foundation of the testing methods. For example, subsections in Chapter 2 include discussions on hyperbolic and dispersive wave motion, Rayleigh and Love waves and a number of mathematical solutions to theoretical surface wave propagation in both elastic and viscoelastic layered continua. It is a highly theoretical chapter and is rigorous and thorough in its treatment of the underlying physics of structure-borne wave propagation.

The book's third chapter begins the detailed examination, finally completed in Chapter 6, of each of the three main phases of the surface wave testing method for site characterization in the near-surface region. In particular, Chapter 3 describes both the theoretical and practical issues related to the first data acquisition phase and covers the *in-situ* measurement of seismic response data from the actual surface wave testing experiments. In contrast to earlier chapters, this chapter is much applied and demonstrates a deep understanding of real-world data acquisition equipment, practices and challenges in the area of SWMs. The second phase of SWM testing consists of signal processing of the experimental data and is discussed in Chapters 4 and 5 with the focus being on the manipulation of the resulting sensor output data to estimate the site region's dispersion and attenuation characteristics, respectively.

The third and final phase in most surface wave testing methods is the determination of the desired site characterization properties using a mathematical process called inversion. Chapter 6 contains details on the theory and mathematical procedures of inversion, which essentially seeks to solve the inverse wave propagation problem to that performed during the test. That is, this chapter's inversion discussion explains how the experimental dispersion and attenuation data, obtained as an output from the processes covered in Chapters 4 and 5, respectively, are further processed in order to determine the site's resulting frequency-dependent shear wave velocity and material damping ratio profiles.

Chapter 7 contains a collection of real-world case studies of the actual sites that are seismically characterized using the surface wave testing methods discussed in the earlier chapters. Unlike the relatively high mathematical tone of some portions of the book (for example, Chapter 2), this chapter is extremely practical, and highly interesting, and demonstrates a considerable amount of hands-on experience by the authors in employing the SWMs in practice.

Finally, Chapter 8, the last chapter in the book, continues the practical emphasis of Chapter 7 on example

applications yet discusses more advanced and state-of-the-art surface wave methods and case studies. For example, the utilization of purely-horizontal motion Love-type waves, with and without coupling to the Rayleigh waves already discussed, is covered in Chapter 8. Similarly, the so-called Scholte waves are discussed for application to underwater site characterization applications. Also discussed in this final chapter are advanced joint inversion methods utilizing multiple datasets and measurements, estimation of additional site properties using the polarization of surface waves and horizontal-to-vertical (H/V) component spectral ratio analyses.

Arguably the most important and impactful factor contributing to the high pedagogical worth of this book is the considerable breadth of the backgrounds and experience levels of the four authors in the varying technical areas that comprise SWMs. Performing an accurate, high quality near-surface site characterization using SWMs fundamentally requires expertise in a number of highly broad fields including fundamental wave propagation physics, real-world data acquisition, advanced signal processing and mathematical methods, and innovative testing methods. The evidence of the authors' collective breadth and depth in each of these required areas is obvious throughout this book.

For example, as mentioned, a rigorous examination of the physics of the underlying wave propagation mechanisms and theories is obvious in the treatment contained in Chapter 2. Then, when a switch to a thorough examination of real-world data acquisition best practices or mathematical signal processing techniques is called for such as in Chapters 3 and 4–5, respectively, the tone changes accordingly and it is obvious that the authors also understand these technical topics in-depth as well. Yet, while it is obvious that the authors possess the ability to dive deeply into each of the technical capabilities that span the very wide spectrum of the book's subject area, the complete book is very cohesive and consistent.

Overall, the book reads as a single unified treatment of the subject area and avoids the common pitfall of appearing to be a collection of separate but related topic areas written by different authors. The text's prolific figures are all non-colored but are of high quality and very illustrative. References are plentiful, current (the majority of them are dated on/after 1998), and appear to represent a broad spectrum of the literature and researchers in the area of SWMs for near-surface site characterization. There are unfortunately no problem sets at the end of each chapter which would appear to limit the use of this book in an academic setting. However, for both those researchers interested in the detailed physics and mathematics underlying the method as well as for practitioners interested in proper application of the SWMs to real-world site characterization, this book is highly recommended.

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