Bridge Monitoring
using the WaveBook™

Transportation

Application Note #27

A bridge is able to support the vehicles and equipment that travel across it primarily because of the support pilings buried in the ground beneath it. Support-piling depth is one of several factors that determine a bridge's load-carrying capacity.

Over many years, weather erodes the earth's surface, exposing the support pilings and reducing a bridge's load-carrying capacity. During periodic bridge inspections, civil engineers are faced with the task of determining the exact support-piling depth so that they can accurately calculate a bridge's load-carrying capacity.

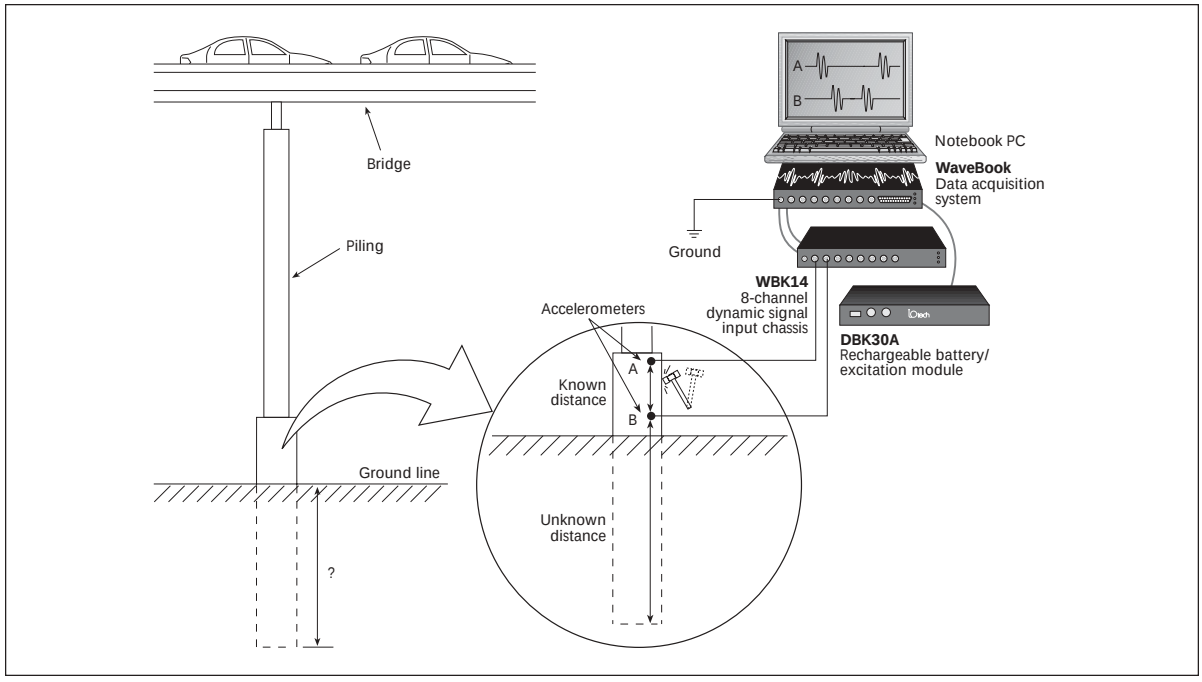
Application Summary

One leading civil-engineering consulting firm has developed an easy-to-use, nondestructive solution to accurately determine the support-piling depth using a portable, high-speed data acquisition system. The civil engineers placed a data acquisition system adjacent to the support piling under test and attached two ICP®-style accelerometers on the structure at a fixed distance from one another. Using a "striker," (a radio-controlled mechanical mallet), the civil engineers tapped the support piling to create wave-front vibrations. The data acquisition equipment then tracked the travel and reflection of the wave fronts via the two attached accelerometers. The civil engineers compensated for the unique vibration characteristics of the support-piling materials (wood, stone, concrete) with a custom software program that accurately calculates the support-piling depth using the recorded wave-front data.

Potential Solutions

The civil engineering firm's original data acquisition solution was extremely bulky and difficult to transport. It consisted of a digital storage oscilloscope (DSO), ICP®-style accelerometers, signal-conditioning equipment for the accelerometers, a data acquisition board installed in a desktop computer, and a generator to power the system components. For travel to the test site, this system was mounted in a large work van, which made it extremely difficult for the civil engineers to get close to the pilings. Often, the engineers were forced to use 100-ft lead lengths to connect the data acquisition system with the accelerometers on the support piling under test. This was a problem because long leads create noise in measurements.

The system setup also had other weaknesses. Because of the DSO's limited memory, the civil engineers had to acquire data at varying sample rates (200 kHz - 50 kHz) to capture entire events. Furthermore, the generator that powered the data acquisition system was extremely noisy, making it difficult to acquire accurate readings.



The bridge piling test set-up

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the smart approach to instrumentation™

The civil engineers decided to search for a data acquisition solution that was easy to transport and could operate without a generator. They considered installing their PC plug-in A/D board into a "luggable" computer or a notebook PC with a docking station. Although these solutions were easier to transport than the DSO, they still required the use of a generator.

IOtech's Solution

The civil engineers finally located a system that perfectly suited their application—IOtech's 1-MHz WaveBook™ digitizer equipped with a WBK18™ dynamic signal input module, a battery pack, and a laptop. This system's light weight and battery power allow the civil engineers to place it close to the support pilings so that they can use shorter leads to attach accelerometers, resulting in greater accuracy.

The WaveBook's 1-MHz A/D converter enables the sampling of two channels at 500 kHz each. The WBK18 dynamic signal input module provides the excitation current and amplification required for the ICP®-style accelerometers. The WaveBook's analog-level triggering and pre-trigger capability allow the engineers to record the strike at the required time so they record only the data necessary for performing their calculations.

Although the civil engineers use a custom analysis software program to calculate the precise support piling depth, the WaveBook includes Windows®-based WaveView™ software for the real-time display of each "hit." This lets the engineers validate their data in the field.

Conclusion

The WaveBook system's light weight, ease of use, and low cost enable civil engineers to easily and accurately monitor the bridges. Not only has the system improved the engineers' ability to determine bridges' accurate and safe load-carrying capacities, it has also prevented bridges from being subjected to unwarranted load restrictions.

WaveBook Series

The WaveBook™ series of portable and desktop digitizers offer multi-channel waveform acquisition and analysis for portable or laboratory applications. All WaveBook models include 8 built-in channels expandable up to 72 channels of voltage, accelerometer, microphone, strain gage, thermocouple, position encoder, frequency, high voltage, and other signal types. For applications beyond 72 channels, up to four WaveBooks can be combined within one measurement system, for a total capacity of 288 channels. WaveBooks are available with either an Ethernet or parallel connection to a PC.

Features

- PC connection via Ethernet, parallel, PC-Card, or PCI card
- 1 µs/channel scanning of any combination of channels
- Expandable up to 288 high-speed channels
- SYNC connection allows multiple units to measure synchronously
- Add up to 224 lower-speed thermocouple channels
- DSP-based design provides real-time digital calibration on all channels
- Single and multichannel analog triggering with programmable level and slope
- Digital TTL-level and pattern triggering
- Pulse trigger and external clock
- Programmable pre- and post-trigger sampling rates
- Sixteen 1-MHz digital inputs
- Operable from AC line, a 10 to 30 VDC source, such as a car battery, or optional compact rechargeable battery module

Using WaveView software's spreadsheet-style interface, you can easily set up your application and begin taking data within minutes of connecting your hardware, with no programming required.

Included Software

- WaveView™ for *Out-of-the-Box*™ setup, acquisition, and real-time display:
  - Scope mode for real-time waveform display
  - Logger mode for continuous streaming to disk
- eZ-Analyst™ for real-time spectrum analysis
- Export data in third-party formats
- Includes drivers for Visual Basic®, Delphi™, C++ for Windows®; DASYLab®, and LabVIEW®
- ActiveX/COM development tools

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