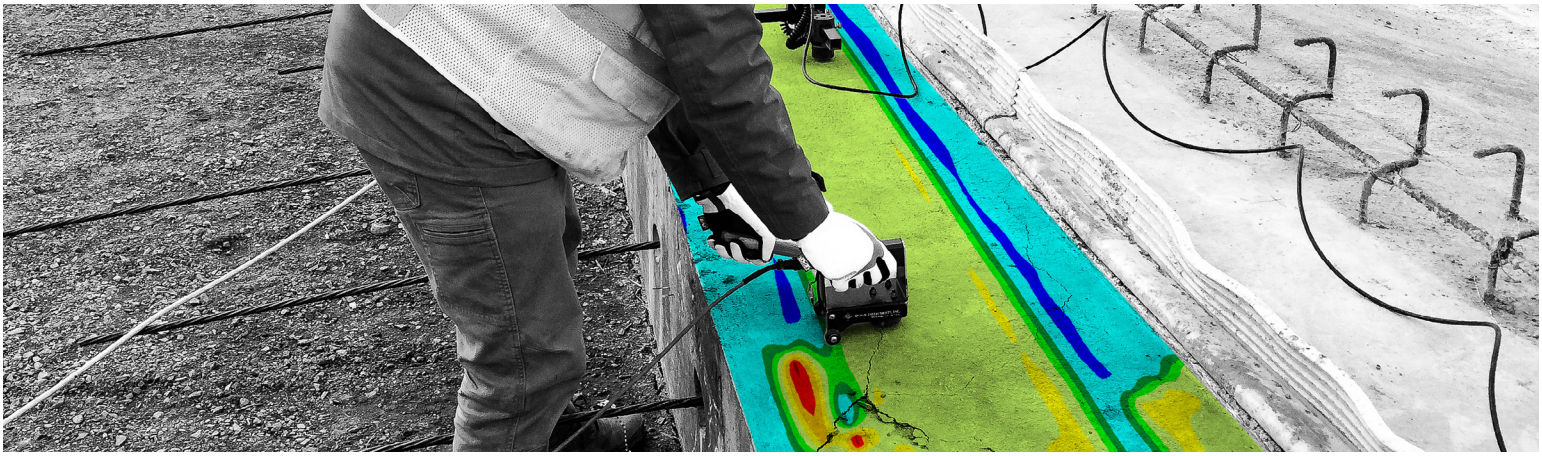
Olson ENGINEERING

IMPACT ECHO (IE)

METHOD BRIEF

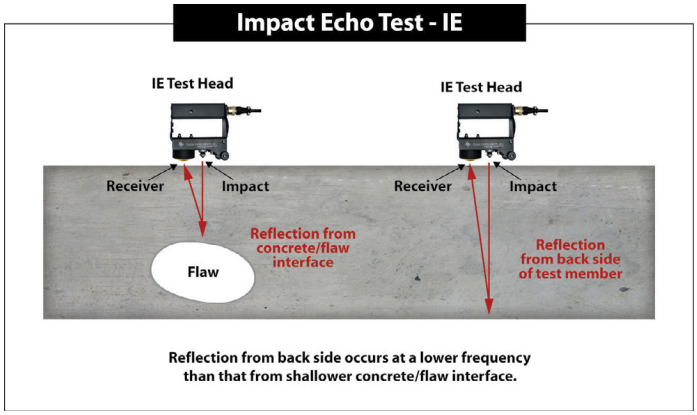


APPLICATION

Impact Echo (IE) investigations are performed to assess the condition of a variety of concrete structures. These include: slabs, beams, columns, walls, pavements, runways, tunnels, and dams. Voids, honeycomb, cracks, delaminations and other damage in concrete, wood, stone, and masonry materials can be identified utilizing the IE method. IE investigations are also performed to predict the strength of early age concrete if the member thickness is known and to measure the thickness of structural members. An advantage of the IE method over the UltrasonicPulse Velocity (UPV) method is that only one side of the structure needs to be accessible for testing. The IE method provides information on the depth of a flaw or defect, as well as mapping its lateral location and extent.

For large area investigations such as slabs, walls, bridge decks, beams, pipes, etc. where shallow voids, cracks, or delaminations are of primary concern, Olson Instruments manufactures an IE Scanner (IES), which can record data at one inch increments to determine duct grout condition. The scanning device application of the IE method was developed by Olson Instruments and is a patented technology. We also offer the **Sonic Surface Scanner (SSS-IE)** system for rapid scanning of VERY large flat areas such as warehouse slabs, parking lots, and bridge decks.

For simple investigations on slabs, pipes, or walls where measuring the overall thickness is the primary concern, Olson Instruments manufactures a hand-held Concrete Thickness Gauge (CTG2) based on the Impact Echo principle, which quickly and easily provides the thickness of an unknown concrete member.



STANDARDS

This method is performed in accordance with ASTM C1383 and ACI 228.2.

** See end of document for full references.*

FIELD INVESTIGATION

ACCESS

Only one surface needs to be accessible for receiver placement and hammer or solenoid impact. For IE investigations, relatively smooth, clean surfaces are ideal, but rougher surfaces can still be tested. The figure on the previous page shows the field setup for a conventional IE investigation.

The IE scanning technology uses the Olson Instruments developed Scanner that contains two sources for generating acoustic energy with different primary frequency content and a receiver wheel made up of multiple sensors. Olson Instruments also developed the CTG2 which contains a source and receiver for simple operation.

COLLECTION OF DATA

In IE investigations, a hammer or solenoid impactor is used to generate compressional waves which reflect back from the back of the tested member or from a discontinuity. The response of the system is measured by the receiver placed next to the impact point. The receiver output and sometimes the hammer input, depending on the equipment used, are recorded with a data collection platform coupled with an Impact Echo System (IE-1, IE-2, IES, or CTG2). IE scanning measurements are recorded by an Olson Instruments Data Acquisition Platform equipped with an IES System.

Conventional IE measurements are possible with the Freedom Data PC equipped with an Impact Echo System, the NDE 360 equipped with an Impact Echo system, or a Concrete Thickness Gauge (CTG2) used with a tablet or laptop.

IE scanning measurements are performed with the Olson Instruments Scanner. The scanner is pushed across an accessible surface of the structural element and measurements are taken every inch. A calibrated distance wheel allows the impactor to hit the surface with precise timing and accurate positioning. The data are then automatically processed for identification of thickness echo peaks and signal energy. The identified peaks or energy are processed to calculate thicknesses and the thicknesses are plotted out on a graph of thickness versus location.

DATA REDUCTION

PROCESSING TECHNIQUES

The IE time traces are transformed to the frequency domain via an FFT. Spectrum data is used to determine the depth of reflectors according to the following equation:

D = VP / (2 x f1)

where D is the reflector depth, f1 is the highest amplitude frequency peak identified in the response, and VP is the IE compressional wave velocity. Olson Engineering uses proprietary, internally developed software packages for IE processing and analysis. This software handles data collected using any of our Impact Echo Systems. Often in QA/QC investigations of concrete placement either in slabs or beams, the field data must be immediately analyzed to ensure proper data collection design and parameters. The IE software permits on-site, preliminary analysis to ensure quality data have been collected. The software includes a variety of digital filters, and typically, a high-pass filter is applied to the data in order to clarify echo peaks corresponding to cracks, voids/debonds or the back side of the concrete.

INTERPRETATION OF DATA

The highest amplitude frequency peak is the main indicator of a reflector depth (thickness echo). The presence of additional echo peaks can also be significant, indicating the presence of possible defects or other interfaces in the concrete. Shape effects due to beam boundaries, or from an elevated slab positioned directly on a beam, can influence thickness measurements. When round void/debond areas exist, the thickness echo peak is often shifted to a lower frequency. This causes the slab to appear thicker as a result of a later arrival time around the void/debond area.

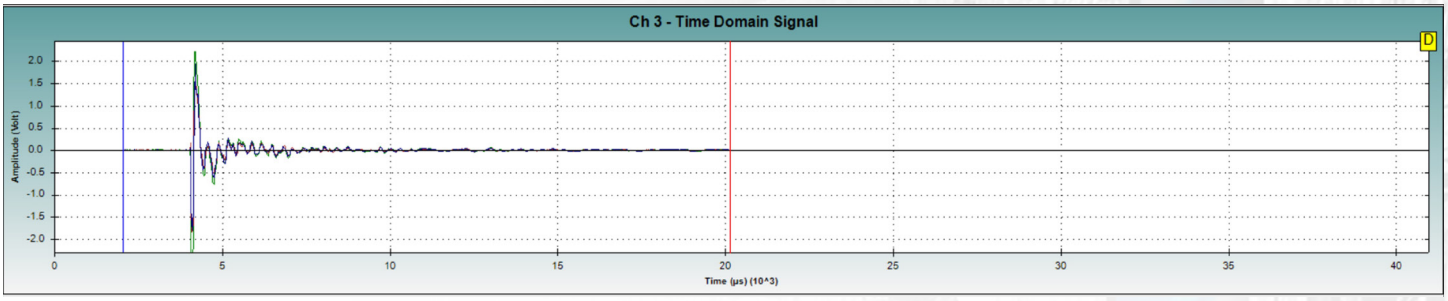
EFFECTIVENESS

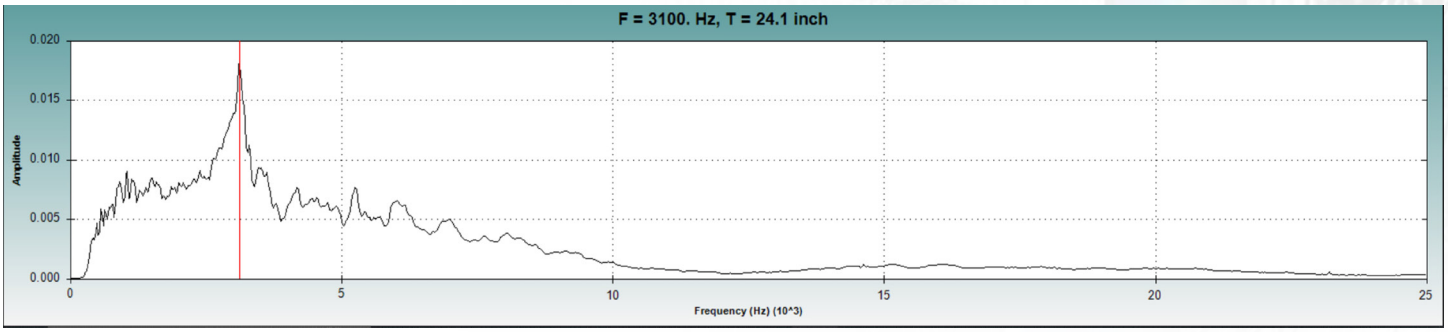
The Impact Echo method requires access to only one side of the structural member being investigated. There are two modes of investigation: thin and thick. These two modes allow for a wide range of thicknesses to be measured utilizing one instrument. For thin members of 3 inches to 10-plus feet thick, a solenoid impactor is used to generate high frequency energy. For thick members of 20 to 48 inches thick, a small hammer is used to generate low frequency energy. Impact Echo investigations can determine member thickness within a 5% accuracy. The IE Scanning method is currently used for investigating shallow void/debond or honeycombing often found between an overlay on a bridge deck or surrounding dense rebar mats. The scanning method is not capable of determining bottom echo thicknesses beyond about 24 inches.

EXAMPLE RESULTS

CONCRETE LOCATION

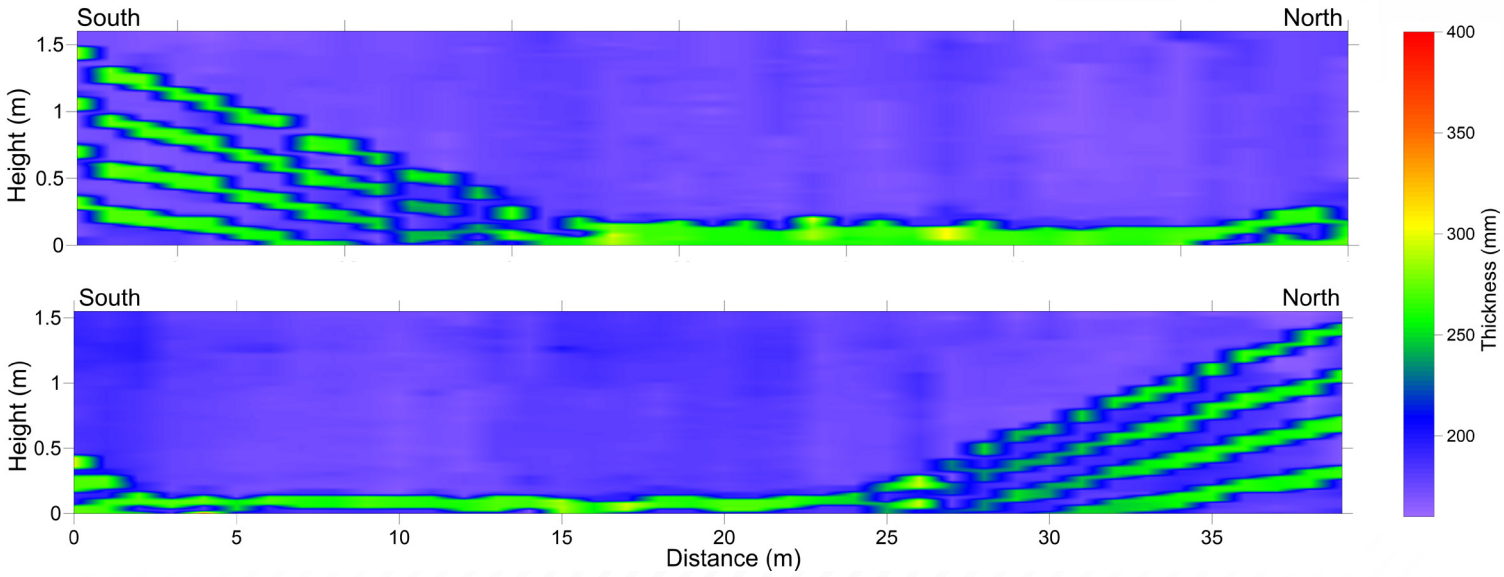
Performing the IE method at a sound concrete location gives results similar to the figure below. A single, sharp, clear peak representing a known thickness is indicative of sound concrete. The slab investigated was 24.0 inches thick and the bottom echo results in a peak at 24.1 inches.





VOIDS IN POST TENSIONED DUCTS

An application of IE Scanning is locating voids in post-tensioned ducts. The figure at right shows the results of scanning a concrete wall with PT ducts. IE scanning was performed on and off the centerline of the ducts.



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REFERENCES

OLSON ENGINEERING PUBLICATIONS

- "Impact-Echo Scanning for Internal Grout Evaluation in Post-Tensioned Ducts," *Yajai Tinkey, Larry D. Olson, P.E., and L. C. Muszynski*, Publication in the Proceedings of Seventh CAMNET/ACI International Concrete Conference on Recent Advance in Concrete Technology, to be published May of 2004.

- "Impact-Echo Scanning of Concrete Slabs and Pipes," *Dennis Sack and Larry D. Olson, P.E.*, Advances in Concrete Technology, The 2nd CANMET/ACI Intl. Symposium, Las Vegas, NV, pp. 683-692, 1995.

- S^3 Paper (2010 - 2015)

- "Impact-Echo Scanning of Concrete Slabs and Pipes," *Dennis Sack and Larry D. Olson, P.E.*, Advances in Concrete Technology, The 2nd CANMET/ACI Intl. Symposium, Las Vegas, NV, pp. 683-692, 1995.

STANDARDS AND GOVERNMENTAL REPORTS

- C1383, "Standard Test Method for Measuring the P-Wave Speed and the Thickness of Concrete Plates Using the Impact-Echo Method," Book of Standards Volume 04.02, ASTM International.

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