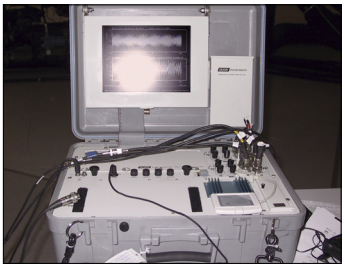
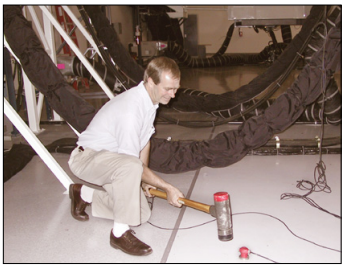
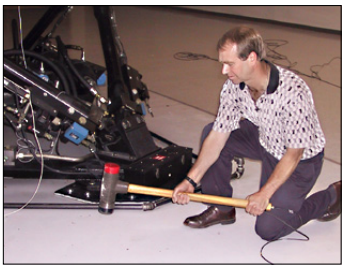
SLAB IMPULSE RESPONCE [SLAB IR]



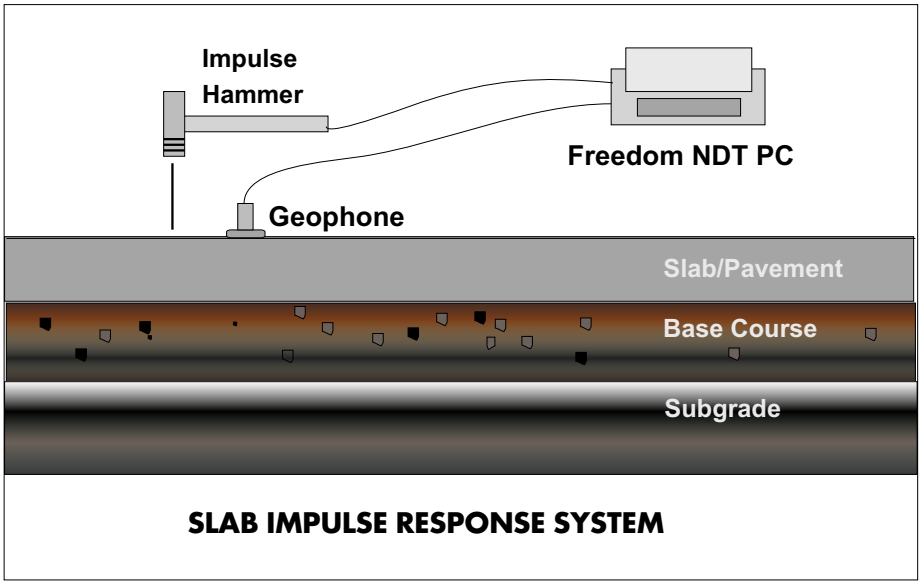




APPLICATION

Slab Impulse Response (Slab IR) investigations are performed primarily to identify subgrade voids below slabs-on-grade. *The method is excellent for evaluating the repair of slab subgrade support conditions by comparing the support conditions before and after repairs.* The elements that can be tested include, concrete slabs, pavements, runways, spillways, pond and pool bottoms, and tunnel liners. The Slab IR method is often used in conjunction with GPR for subgrade void detection and mapping.

In addition, the Slab IR test method can be used on other concrete structures to quickly locate areas of delamination or void in the concrete, if the damage is relatively shallow. Slab IR can be performed on reinforced and nonreinforced concrete slabs as well as asphalt or asphalt-overlay slabs. The schematic below shows the field setup used in Slab IR investigations.



SLAB IMPULSE RESPONSE SYSTEM

STANDARDS

Standards for the CSL method include ASTM D6760-02 for integrity testing of concrete deep foundations and ACI 228.2R for NDE applications, and FLH 521.830 for determining pulse velocity through concrete in drilled shafts. See end of document for full references.

- **See end of document for full references.**

FIELD INVESTIGATION

ACCESS

The Slab IR method requires access to the top surface for receiver locations and hammer hitting. The receiver is mounted to the surface of the slab adjacent to the impact location and generally 3-4 inches away.

COLLECTION OF DATA

In a Slab IR investigation, the slab top is impacted with an impulse hammer and the response of the slab is monitored by a geophone placed next to the impact point. The hammer input and the receiver output are recorded by an Olson Instruments Freedom Data PC equipped with the Slab Impulse Response System (SIR-1). In easy access areas, **400-600 Slab IR tests can be performed in an 8 hour work day.**

DATA REDUCTION

PROCESSING TECHNIQUES

Fast Fourier Transform (FFT) operations performed by the Slab IR software in our Freedom Data PC transform the impulse force and vibration velocity response time domain signals to produce a plot of mobility (vibration velocity/pounds force). After transformation to the frequency domain, the transfer and coherence curves are automatically generated by the Freedom Data PC Slab IR software. Analysis of the mobility plot provides information on the subgrade support conditions within a radius of 0.5 to 1.0 foot from the test point depending on slab thickness.

INTERPRETATION OF DATA

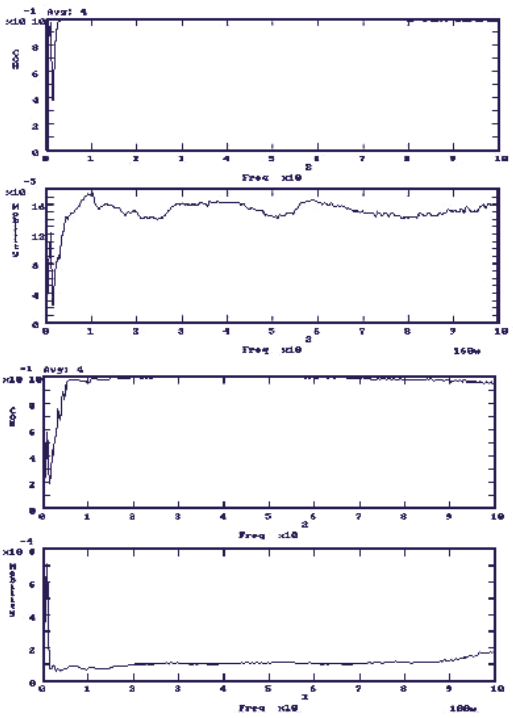
Support condition evaluation includes two measurement parameters. First, the dynamic stiffness is calculated. The initial slope of the mobility plot indicates the quasi-static flexibility of the system. The steeper the slope of the initial part of the mobility plot, the more flexible and less stiff the system is. Second, the shape and/or magnitude of the mobility plot above the initial straight line portion of the curve is an indication of support condition. The response curve is more irregular and has a greater mobility for void versus good support conditions due to the decreased damping of the slab vibration response for a void. The presence of a high-amplitude, low frequency spike in the mobility plot is an additional indication of void conditions.

EFFECTIVENESS

The Slab IR method is used to determine the support conditions of the slab and to map out the aerial extent of any void or poor support condition zones, but the method cannot determine the thickness of any voids found. Collecting Slab IR data at multiple, densely-spaced locations can improve the conclusions by mapping relative areas of higher and lower mobility. However, relatively low mobility does not indicate the absence of a subgrade void, but qualitatively indicates that such an area appears to be more solidly supported than an area with relatively high mobility. For thick slabs (thickness > 2 ft), the interpretation of the Slab IR data becomes difficult because the stiffness of the system is controlled by the slab itself and not by the support conditions under the slab.

Example Results

To illustrate the concepts of the Slab IR test, example results from an investigation performed on a highway entrance ramp are presented below. The images show the resulting mobility profile for the ramp. The color scale is read such that white space equates to low mobility and green equates to high mobility. Mobility corresponds with flexibility. The flexibility is represented by the blue diamonds, the larger the diamond the larger the higher the flexibility (refer to page 5).



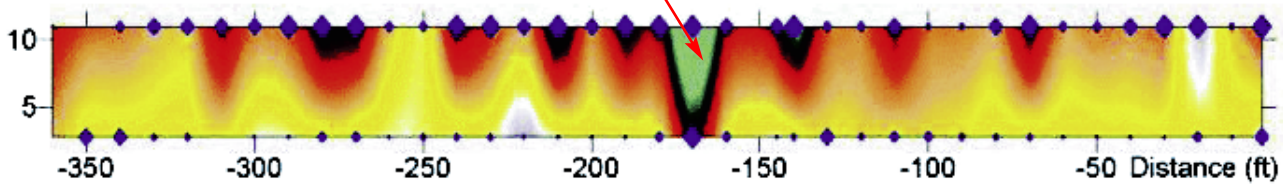
Example Coherence and Mobility Plots

The figure shows mobility for void and sound subsurface conditions, respectively. In both cases, the upper curves for coherence indicate good data quality.

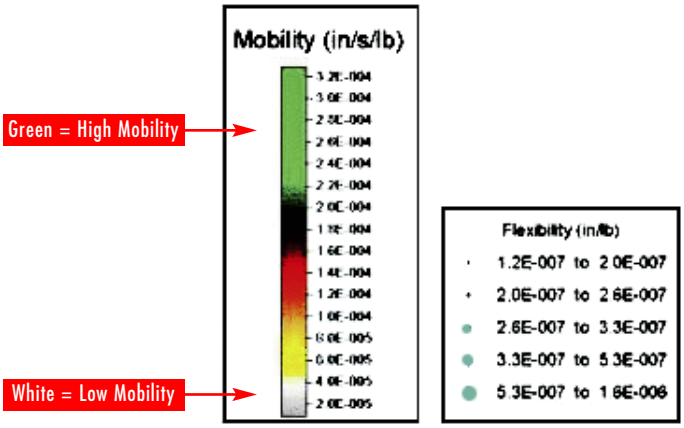
Example Results *cont.*

The example is a technique used to produce an image or contour map of the data collected. When analyzing data collected on a particular site, clear results will appear much like the figure below. Good subgrade support will result in high coherence and low mobility, poor subgrade support will result in high coherence and high mobility. The image below is of good subgrade support, the image on next page is of poor subgrade support. The coherence is related to the coupling of the transducer to the member. This can be an indication of poor coupling if the coherence is poor.

Evidence of water infiltration causing bulging Mechanically Stabilized Earth (MSE) wall correlates to area of high relative mobility.



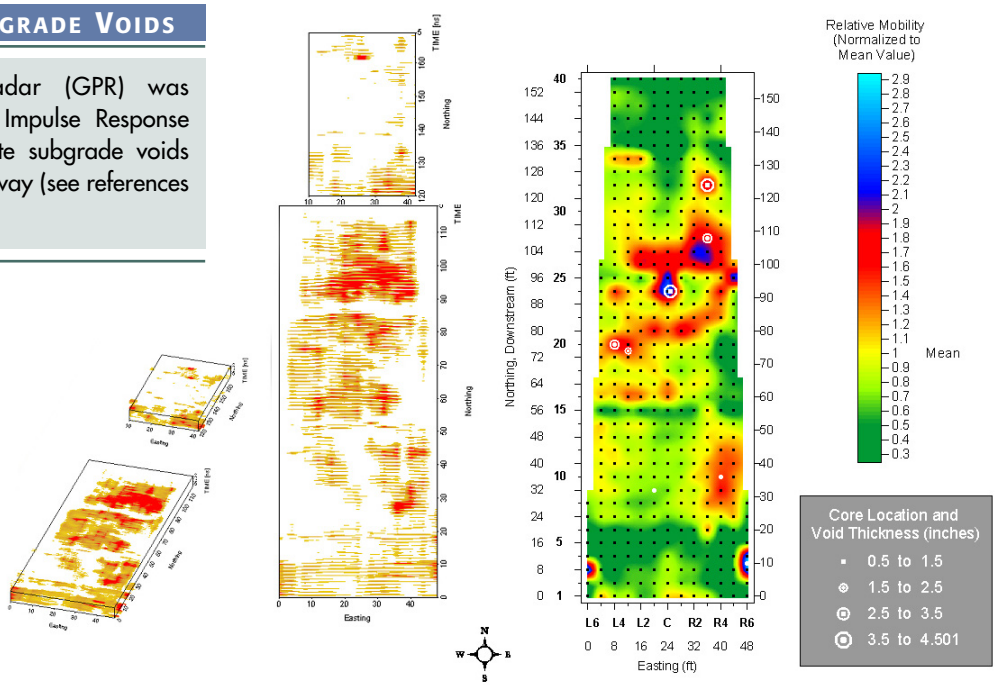
Slab Impulse Response (Slab IR) Results
Flexibility/Mobility Plot



EXAMPLE RESULTS *cont.*

STRUCTURAL - SUBGRADE VOIDS

Ground Penetrating Radar (GPR) was combined with the Slab Impulse Response (Slab IR) method to locate subgrade voids below an alpine dam spillway (see references for full text).



REFERENCES

OLSON ENGINEERING PUBLICATIONS

- "Application of a Combined Nondestuctive Evaluation Approach to Detecting Subgrade Voids Below a Dam Spillway," Hollema, David A., Olson, Larry D. (2004) SAGEEP 2004.

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