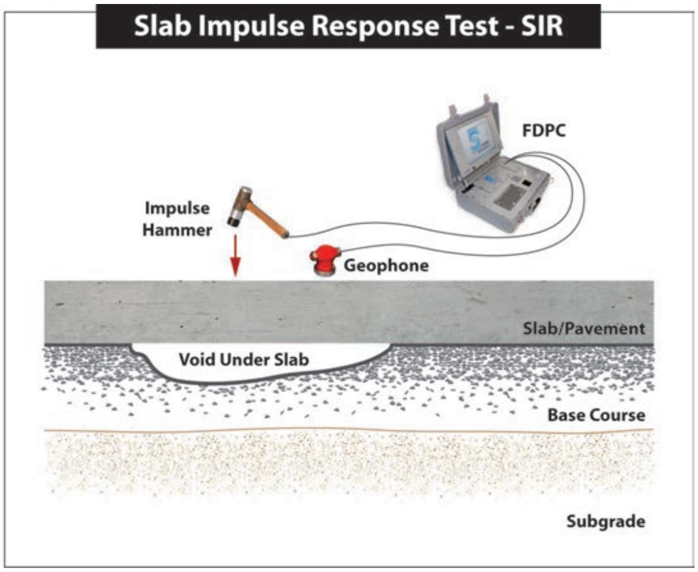
SLAB IMPULSE RESPONSE (SIR)

METHOD BRIEF

APPLICATION

Slab Impulse Response (SIR) investigations are performed primarily to identify and map out subgrade voids below slabs-on-grade. The SIR method is also 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.

The Slab IR test method can also be used on other concrete structures to quickly locate areas of shallow delamination or void. 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.



STANDARDS

Standards for the SIR method include ASTM C1740 for evaluating the condition of concrete plates, using the Impulse-Response method and ACI 228.2R for NDE.

** See end of document for full references.*

FIELD INVESTIGATION

ACCESS

The Slab IR method requires access to the top surface of the test structure for receiver placement locations and hammer impacting. The receiver is held firmly against the surface of the slab and the slab is impacted at a point about 3-6 inches away.

COLLECTION OF DATA

In an SIR investigation, the slab top is impacted with an impulse hammer and the response of the slab is monitored by a geophone or other velocity transducer placed adjacent to the impact point. The hammer input and the receiver output are recorded by an Olson Instruments Data Collection Platform equipped with an SIR System. In easy access areas 400-800 Slab IR tests can be performed in an eight-hour work day.

FDPC

SIR System

NDE 360

DATA REDUCTION

PROCESSING TECHNIQUES

Fast Fourier Transform (FFT) operations performed by Olson's SIR software transform the impulse force and vibration velocity response time domain signals to produce a frequency domain plot of mobility (vibration velocity/pounds force). After transformation to the frequency domain, the transfer function and coherence curves are automatically generated. Analysis of the mobility plot provides information on the subgrade support conditions within a radius of 6 to 12 inches (15 to 30 cm) from the test point, depending on slab thickness.

INTERPRETATION OF DATA

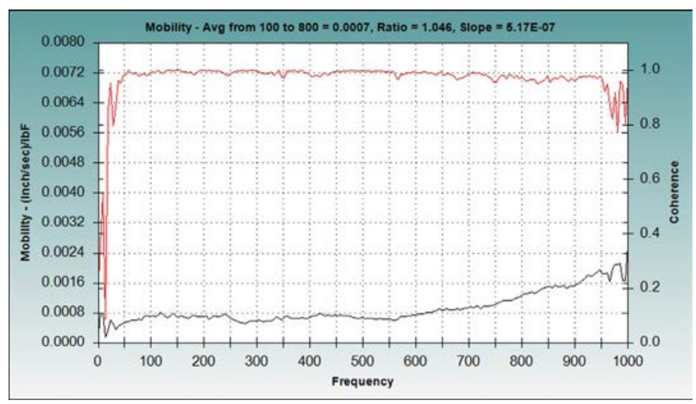
Support condition evaluation includes two measurement parameters. First, the dynamic stiffness is calculated. The initial slope of the mobility plot indicates the quasi-static flexibility of the system. The steeper the slope of the initial part of the mobility plot, the more flexible and less stiff the 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

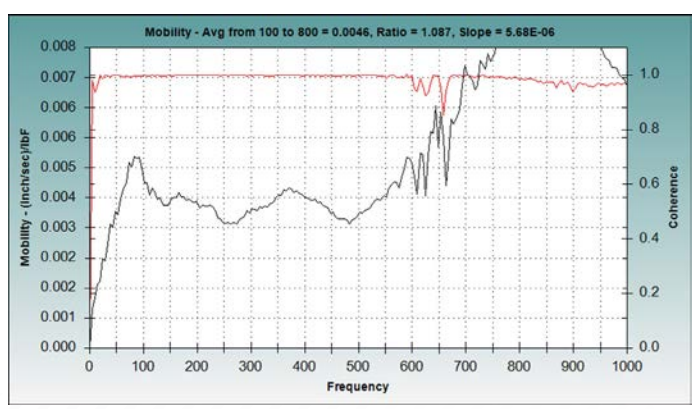
The SIR method is used to determine support conditions of a slab and to map out the areal extent of any void or poor support condition zones, but the method cannot determine the thickness of any voids found. Collecting Slab IR data at multiple, densely-spaced locations can improve the conclusions by 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 > 1.5 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

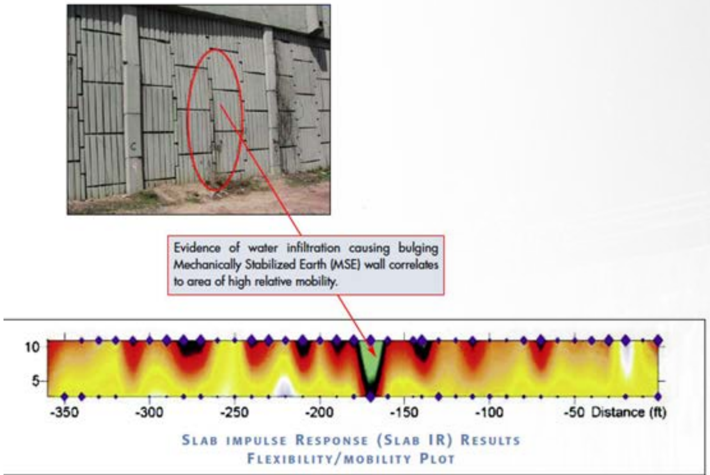
To illustrate the concepts of the SIR test, example results from data collection on the wall of a highway entrance ramp are presented below.



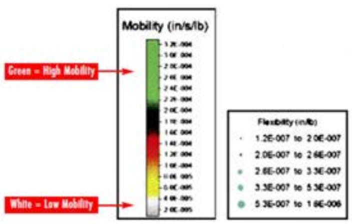
Sound Example Record



Subgrade Void Example Record



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



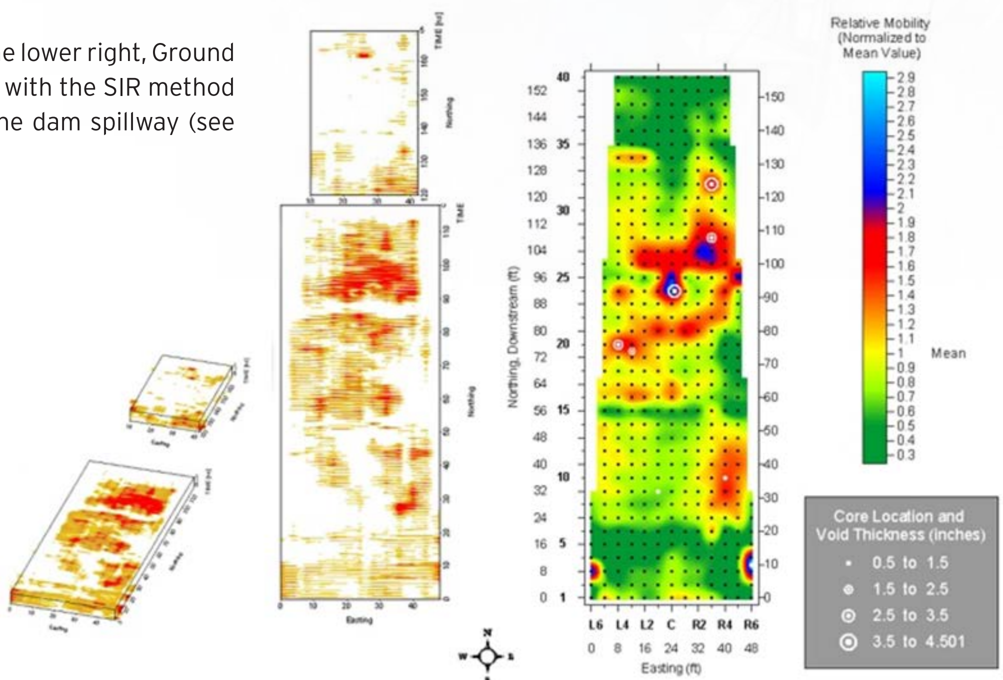
EXAMPLE COHERENCE AND MOBILITY PLOTS

The top two plots in each figure show the coherence (data quality) versus frequency for void and sound subsurface conditions. The bottom two plots show the mobility for both sound (upper figure) and void (lower figure) subsurface conditions. Note that the upper curves for coherence indicate good data quality in both cases.

The results can be used to produce an image or contour map. When analyzing data collected on a particular site, clear results will appear much like the image below, which shows the resulting mobility profile for the ramp. In this plot, white represents areas of low mobility and green represents areas of high mobility. Mobility corresponds with flexibility. The flexibility is represented by blue diamonds, the larger the diamond, the higher the flexibility. Good subgrade support will result in high coherence and low mobility, while poor subgrade support will result in high coherence and high mobility. The coherence is related to the coupling of the transducer to the member and the repeatability of the test data at the same location. If the coherence is poor, it can be an indication of poor coupling or poor quality data.

STRUCTURAL – SUBGRADE VOIDS

In the example shown in the figures on the lower right, Ground Penetrating Radar (GPR) was combined with the SIR method to locate subgrade voids below an alpine dam spillway (see references for full text).



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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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