s’MASH

Purpose

For a long time, users of NDT systems have wished for a rapid, easy to use method for rapid screening of the integrity of structures. The **s´MASH** impulse-response test system fulfills this wish. The idea is to quickly screen a structure for flaws and identify suspect areas for subsequent detailed analysis, e.g. by the impact-echo test (using the **DOCter**), pulse-echo testing (with **MIRA** or **EyeCon**), or by invasive inspection with drilled cores (using **CORECASE**).

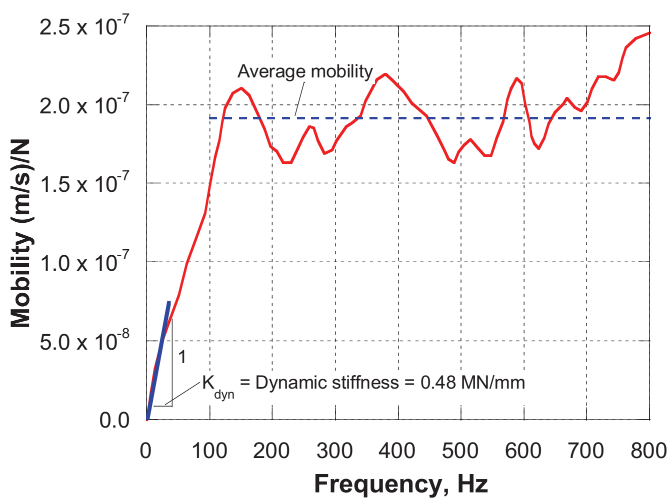
With the **s´MASH**, rapid evaluation can be conducted for:

- Detecting voids beneath concrete slabs in highways, spillways and floors
- Detecting the curling of slabs
- Evaluating anchoring systems of wall panels
- Locating delaminations and honeycombing in bridge decks, slabs, walls and large structures such as dams, chimney stacks and silos
- Detecting the presence of damage due to freezing and thawing
- Detecting the presence of alkali-silica reaction (ASR)
- Detecting debonding of asphalt and concrete overlays and repair patches from concrete substrates
- Evaluating the effectiveness of load transfer system in transmitting stresses across joints in concrete structures

Principle

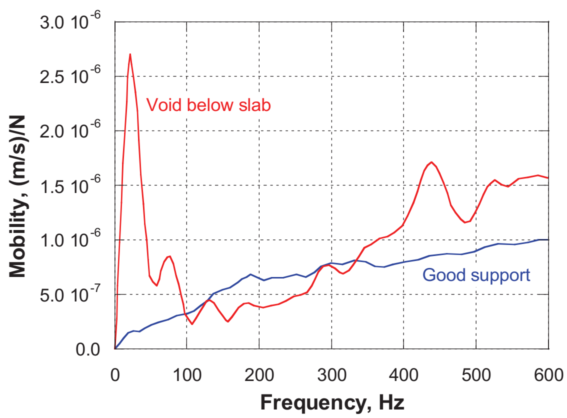
The **s´MASH** uses a low-strain impact, produced by an instrumented rubber tipped hammer, to send stress waves through the tested element. The impact causes the element to vibrate in a bending mode and a velocity transducer, placed adjacent to the impact point, measures the amplitude of the response. The hammer load cell and the velocity transducer are linked to a portable field computer with **s´MASH** software for data acquisition, signal processing and storage.

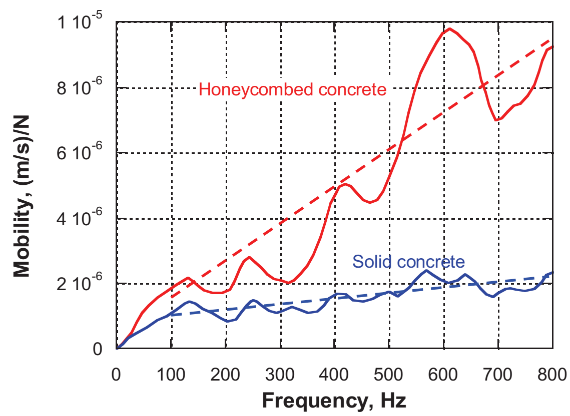
The time histories of the hammer force and the measured response velocity are transformed into the frequency domain using the fast Fourier transform (FFT) algorithm. The resultant velocity spectrum is divided by the force spectrum, to obtain the **mobility** as a function of frequency. An example of such a mobility plot is given below for a solid concrete member. Mobility is expressed in units of velocity per unit force, such as (m/s)/N.



The parameters from the mobility plot that are used for integrity evaluation are:

- The **dynamic stiffness** (the inverse of initial the slope of the mobility plot, the blue line in previous figure;
- The **average mobility** (dotted blue line in previous figure);
- The **mobility slope** between 100 to 800 Hz; and
- The **voids ratio** (the ratio of the amplitude of the initial mobility peak to the average mobility)



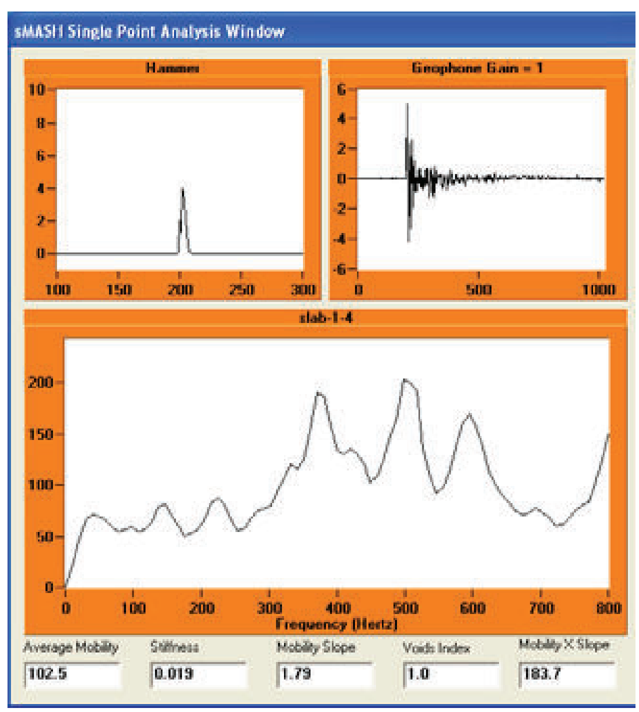


Examples of mobility plots for different types of flaws are shown above. The figure on the left compares the mobility plot for a slab-on-ground with a void below the slab with the mobility plot for a slab with uniform support. The **voids ratio** is the ratio of the amplitude of the peak to the average mobility of the slab with good support. The figure on the right figure compares the mobility plot of a honeycombed region in a silo wall with the mobility plot of properly consolidated concrete. Honeycombed concrete is typically associated with a high **mobility slope** (the dashed lines).

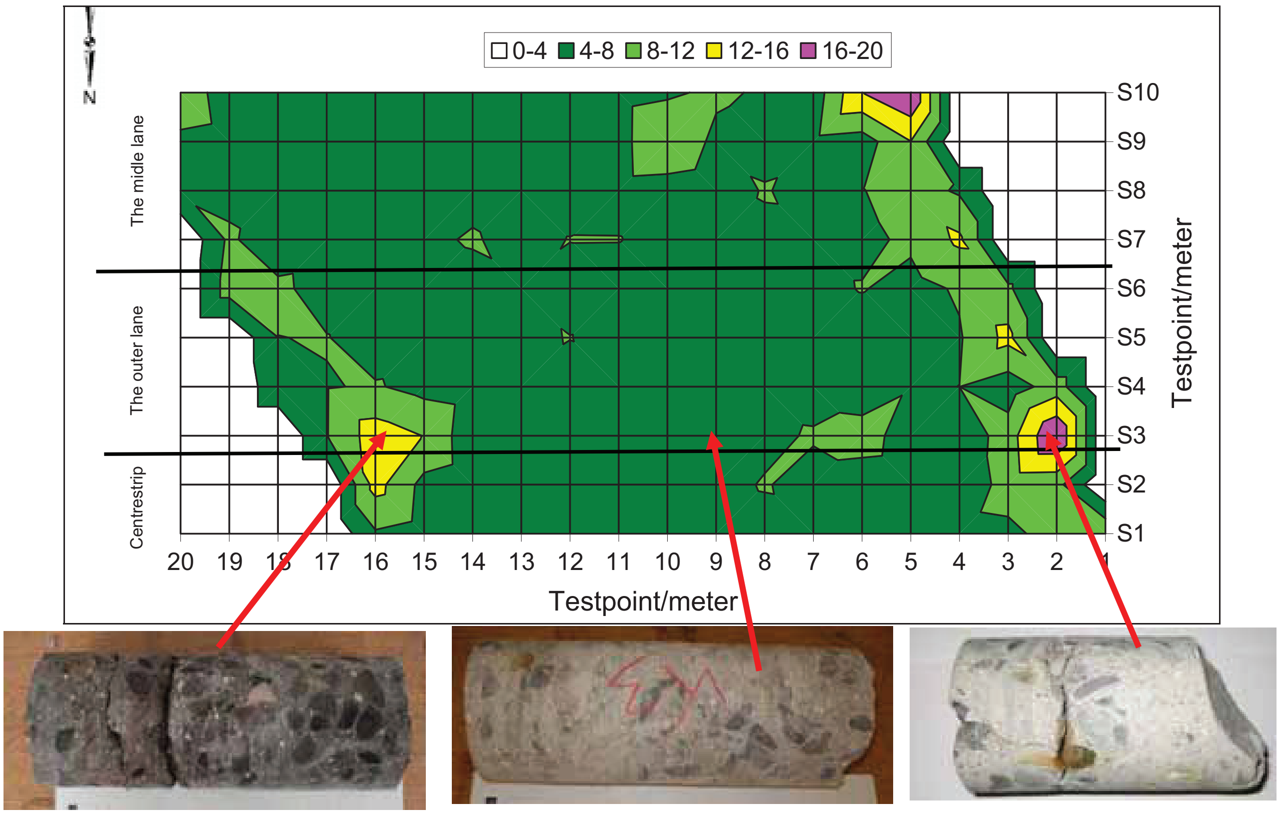
Testing is performed on a grid marked on the surface of the structure. The **s'MASH** software constructs color contour plots of the various parameters, from which it is easy to identify anomalous regions of the structure that merit detailed investigation. This is done on-site after the testing has been completed, producing immediate information of the presence of anomalies.

Testing Examples

Shown on the right is the result of one test as displayed on the computer with the **s'MASH** software. The top left window is the force-time curve obtained from the impact of the instrumented hammer. The top right window shows the velocity-time curve obtained from the geophone in contact with the concrete surface. The figure in the lower window is the mobility plot obtained from the previous two waveforms. The bottom of the display shows the various parameters calculated from the mobility plot.



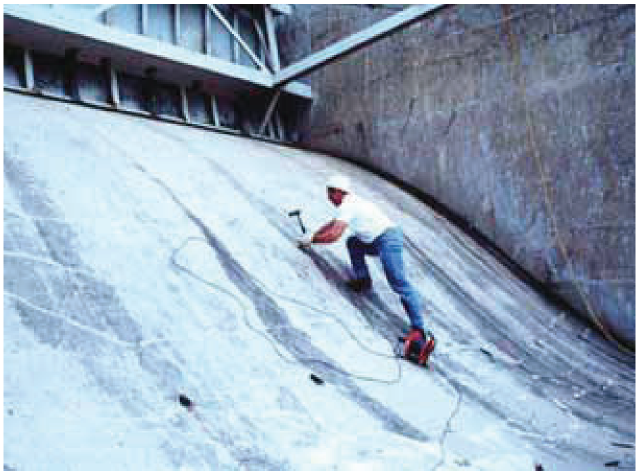
Below is the contour plot of the average mobility from **s’MASH** tests performed on the soffit of a bridge slab that was suspected of containing delaminations. Tests were performed on a 1 × 1 m grid. Based on the contour plot, cores were drilled at three locations: (1) a region of low mobility, (2) a region of intermediate mobility, and (3) a region of high mobility. The cores confirmed that low mobility corresponded to a sound slab and higher mobility corresponded to the presence of delaminations.



Testing Applications

Testing for voids behind tunnel lining

Testing for honeycombing in slip-formed silo



Testing for delaminations in dam spillway

Testing for tightness of joints of concrete tank

Testing for honeycombing and delaminations in bridge piers

Testing for cracking and debonding of limestone cladding

Testing for anchoring quality of granite panels in high-rise building

Testing for internal cracking and debonding of terracotta cladding

s´MASH Ordering Numbers

s´MASH-4000 Instrument Case

Item	Order #
Instrumented hammer	s´MASH-4000-10
Calibration certificate for hammer	s´MASH-4000-20
Rubber tip for regular testing	s´MASH-4000-30
Aluminum tip for pile testing	s´MASH-4000-40
Transducer for 360° testing	s´MASH-4000-50
Calibration certificate for horizontal transducer	s´MASH-4000-60
Belt box with 3 m cable	s´MASH-4000-90
Manual	s´MASH-4000-100
Attaché case	s´MASH-4000-110

The instrumented hammer and the transducers need to be calibrated once a year.

s´MASH-4000 Computer Case

Item	Order #
Computer with Windows®, Excel®, and s´MASH software installed	s´MASH-4000-200
s´MASH software, CD-ROM	s´MASH-4000-210
Amplifier box	s´MASH-4000-220
Protection shield for connecting cable	s´MASH-4000-230
110-220V AC adaptor with cords	s´MASH-4000-240
Attaché case	s´MASH-4000-250

The amplifier box can also be used for **DOCter** impact-echo testing, for spectral analysis of surface waves (SASW) testing, as well as for parallel seismic testing.

A two-day training course is offered separately. The course covers the theoretical background of impulse-response testing, the testing methodology, testing cases from a variety of structures and hands-on training on testing with the s´MASH.

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Test smart - Build right