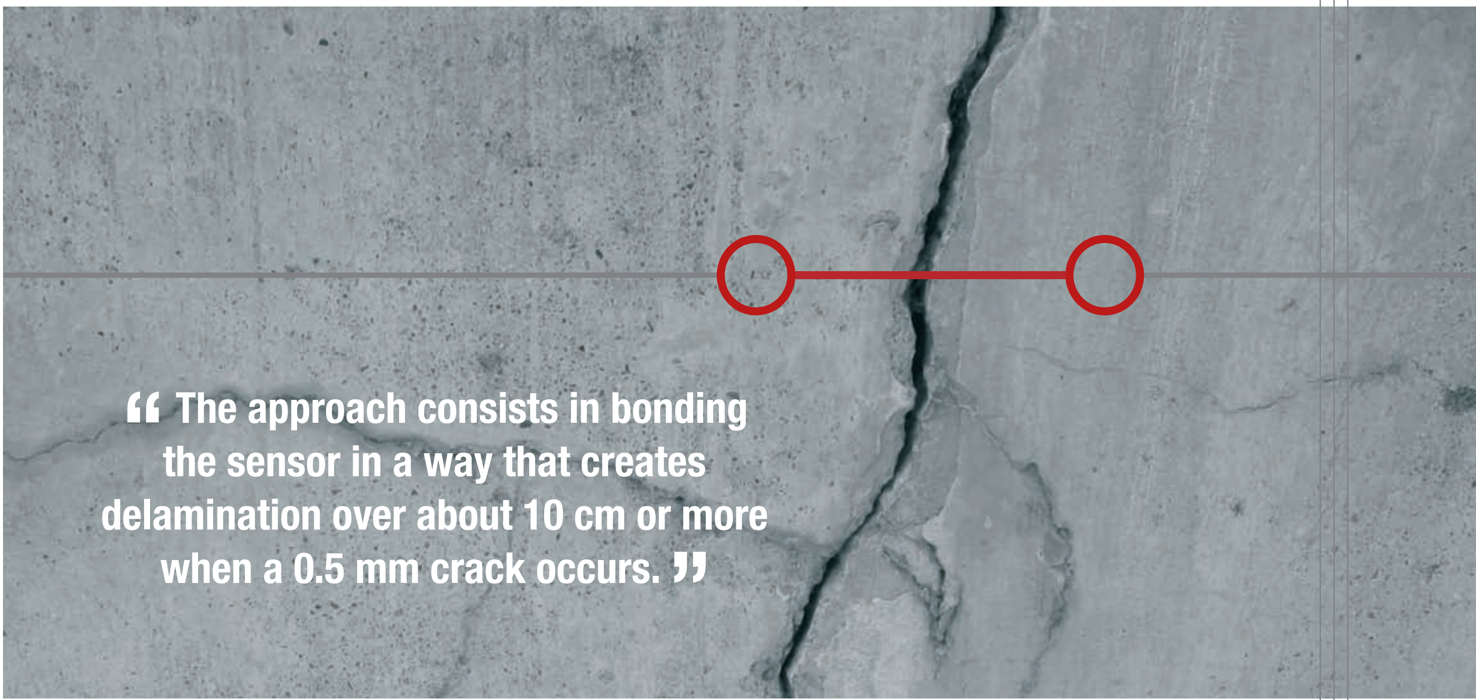
BOTDA



Fiber Optic Crack Detection

FOR CIVIL ENGINEERING APPLICATIONS

Introduction

Structural Health Monitoring has been an important development of the civil engineering field. Recent events remind us that the cost of a bridge collapse is much more than economical, it touches people's life, as dramatically demonstrated by the collapses of the Laval's La Concorde overpass, in fall 2006, and, the Minneapolis bridge, in summer 2007.

The implementation of comprehensive SHM in civil infrastructure is made possible by the use of optical fiber sensors and can substantially improve the safety of civil structures and help to manage them more efficiently.

More specifically, distributed Brillouin-based sensing systems (BOTDA) are capable of measuring strain everywhere along a dedicated optical fiber cable attached to the structure to be monitored. Measurement readings can be taken every meter, which is a clear advantage when localized faults, such as cracks, need to be detected, but their position is not known beforehand.

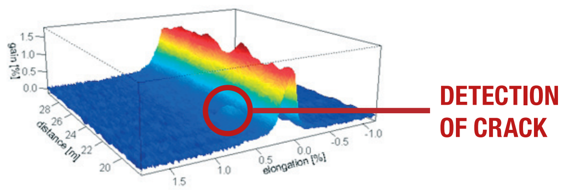
Among the principal aims of Structural Health Monitoring, the detection and localization of cracks appear as an essential task as crack can lead to lethal faults for the structure's life.

Multiple strain contribution

A unique feature of Omnisens DITEST systems is the possibility to detect occurence smaller than the system spatial resolution as these events generate additional peaks in the measured Brillouin spectrum indicating multiple strain contribution at specific location.

The detection of multiple strain contribution is done using a frequency peak search in the Brillouin spectrum and a multiple distribution fitting algorithm.

Omnisens DITEST distributed strain analyzer DITEST-STA include the multiple strain contribution algorithm and are thus able to provide crack detection or inhomogeneous strain contribution within the spatial resolution of the instrument. This approach is extremely efficient for events of about 10 cm.



SWISS MADE

omnisens
Securing asset integrity

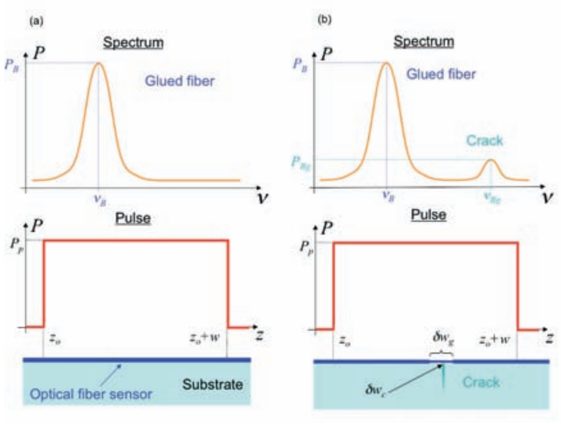
Fiber optic micro-crack detection

There are however challenges associated with crack detection. Crack generates concentrated strain and stress in the optical fiber sensor at the location of its occurrence over distances lower than a millimeter. Strain concentration is so high that it would provoke a rupture of the sensor interrupting the monitoring. Using a high spatial resolution interrogator would then be pointless as the sensing channel is disrupted.

Omnisens crack detection technique addresses that issue by introducing an approach based on a stress transfer mechanism from the crack to the sensor. Such approach avoids any risk of sensor breakage. The fiber sensor packaging and bonding procedure must then be carefully selected to debond over wg. ≈ w/10.

Specific strain sensors such as SMARTape allows accuracte crack detection by appropriate delamination of the bonding interface. The large strain induced by the crack is distributed over the delamination length (~0.1 m) and no longer lead to the sensor rupture. The crack is detected by the multiple strain detection algorithm.

That approach is illustrated in the following Figures.



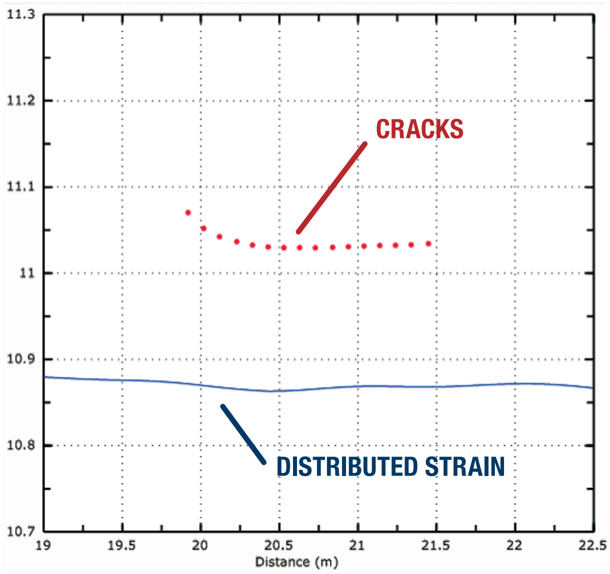
(a) An optical fiber sensor is bonded at the surface of a substrate. A pump pulse of peak power Pp and spatial resolution w propagates down the sensor and interacts with the cw probe. The result of the interaction is a Brillouin spectrum that is characteristics of unstressed fiber.

(b) A crack occurs and delaminate the sensor over a length of wg, crack size length at surface is wc<wg. At the crack location, pump-probe interaction leads to the measurement of a new spectrum experiencing an additional peak, which is a signature of the fault formation.

Typical crack detection give a precise positioning of the crack with 0.1 m accuracy and intuitive graphical interface allowing easy interpretation between standard distributed strain analysis and cracks.

Omnisens has demonstrated that the combination of Omnisens DITEST interrogator with the SMARTEC SMARTape sensing cable successfully detects the opening of sub-millimeter cracks. The proposed method guarantees the sensor uninterrupted operation and allows the detection of sub mm cracks within a 1 m spatial resolution thanks to careful analysis of the Brillouin spectrum shape.

It also reveals the advantage of the Distributed Brillouin Scattering method over other distributed techniques such optical time domain Rayleigh and Raman reflectometers: the BOTDA has an event detection capability smaller than its spatial resolution making BOTDA the monitoring tool of choice when high spatial detection capability is required.



Omnisens SA
Riond Bosson 3, 1110 Morges – Switzerland
T: +41 21 510 21 21 - F: +41 44 274 20 31
sales@omnisens.com
www.omnisens.com

omnisens
Securing asset integrity

REF: TN-002 (Fiber Optic Crack Detection) en-02