Innovation and Networking for Fatigue and Reliability Analysis of Structures – Training for Assessment of Risk

Advanced ultrasonic instrumentation for interferometric monitoring

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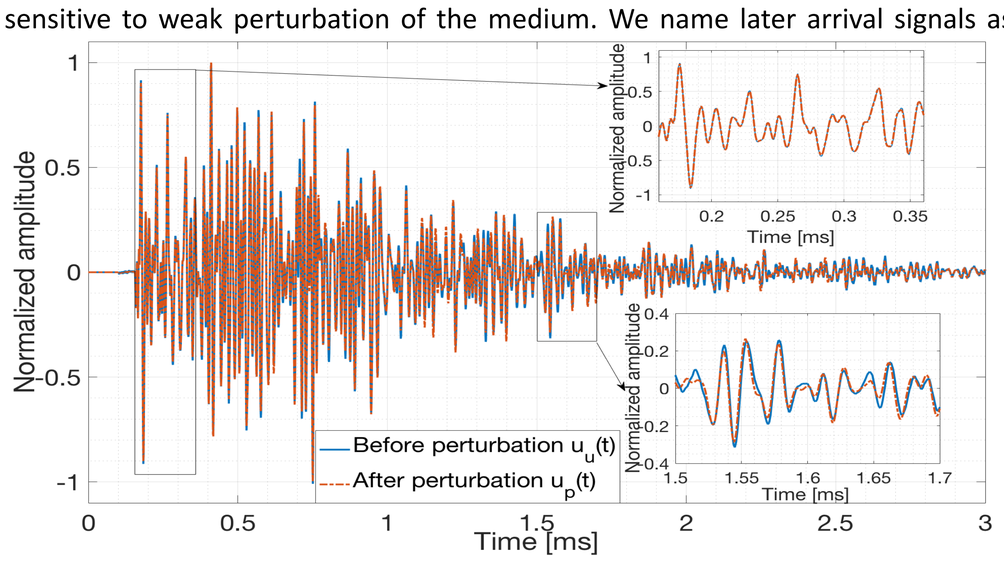
Objectives:

Main aim is to improve ultrasonic sensor networks to monitor concrete structures under dynamic loads. Novel algorithms have to be developed and tested to separate the influence of various effects for field data. Ways to quantify the interpretation of ultrasonic data e.g. in terms of degree of damage or capacity, have to be found. Improve and simplify imaging techniques, extend them to arbitrary structures, to foster field applications.

Method: CWI - CODA Wave Interferometry

CODA Wave

As diffuse waves travel much longer paths than direct or simply reflected ones, they are much more sensitive to weak perturbation of the medium. We name later arrival signals as CODA wave.

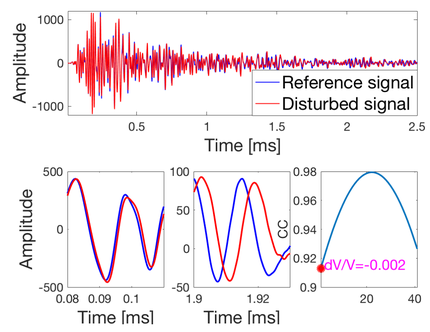


Signal measured before and after subtle change

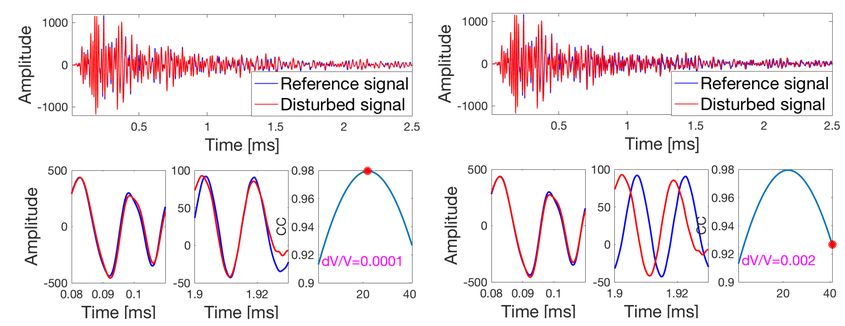
The first part of the signal corresponds well, however, the coda wave shows us the changes of the signal. By analyzing the ultrasonic signals, we can extract 2 useful information, correlation coefficient (CC) which present the similarity of two signals and velocity change.

Stretching method

Choose reference signal → Stretch reference signal with different dilation rates **α** → Calculate CC between new signal and all stretched reference signals → **α** which maximize the CC is the velocity change



This method consider that the result of the velocity change is the dilation (not shift) in time. The compression or dilation of a reference signal with a dilation rate α simulate an increase or decrease of propagation velocity.

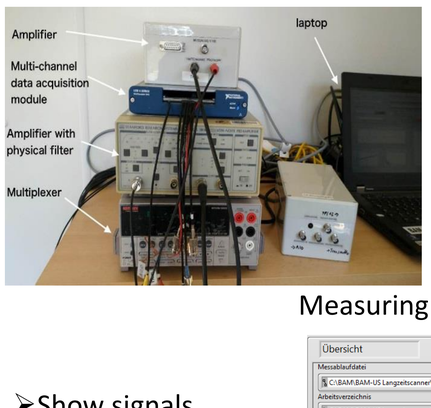


Transducer and data acquisition system

New embedded ultrasonic transducer "SO807"

- Transmitter and receiver at the same time
- More information of the interior of structure
- Easy installation during the construction.
- Less surface waves and less influence from near surface changes

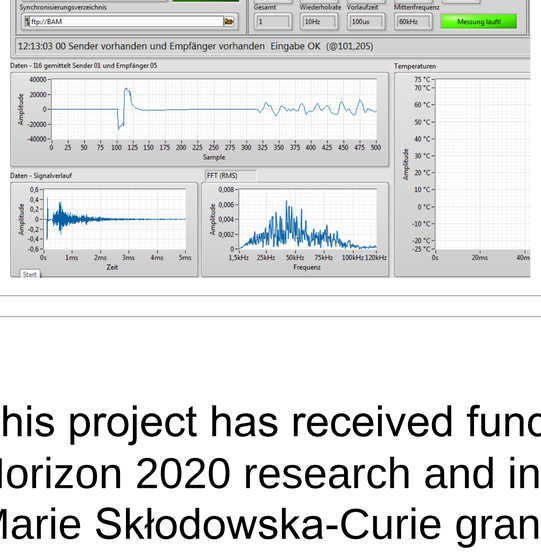
Data acquisition system



- Amplifier
- Multi-channel DAQ
- Multiplexer
- Pre-amplifier with physical filter
- Laptop + Measure program

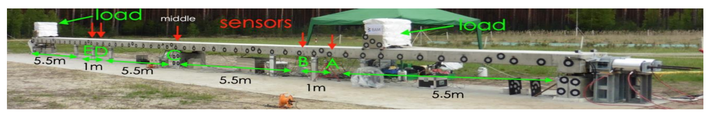
Measuring program

- Show signals
- Show FFT
- Show temperature
- Run automatically
- Change configuration
- Synchronize data to FTP server



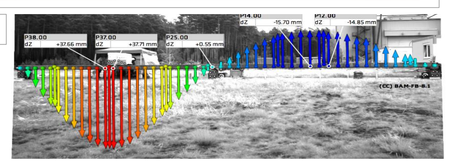
BLEIB reference structure (shared object for INFRASTAR project)

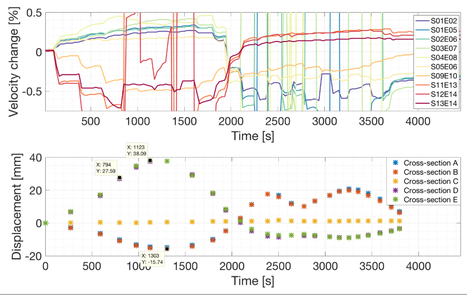
A 25 meters long pre-tensioned reinforcement concrete beam with multiple sensors installed such as ultrasonic sensors(14 SO807), fiber optics sensors, etc. Two loads of 2 tons are used for the static test



stereo photogrammetry system

- Bending tensile stress increased ←→ Velocity change decreased
- Compression stress increased ←→ Velocity change increased



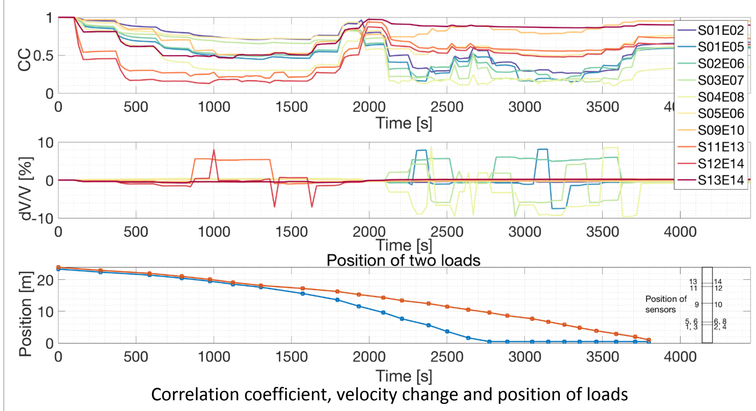


- Level of velocity change and displacement has same trend

Step 11: Min displacement
- D, E : -2mm
- A, B : 2mm
- C : ≈ 0mm

Step 7: Max displacement
- D, E : 37mm
- A, B : -13mm
- C : ≈ 0mm

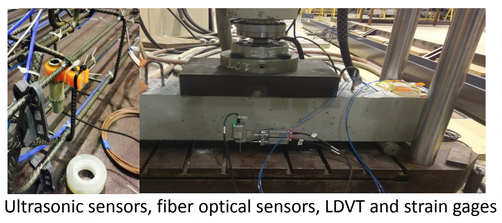
Static test:
The position of the two loads change step by step from the right extremity of BLEIB structure to the left extremity.



Correlation coefficient, velocity change and position of loads

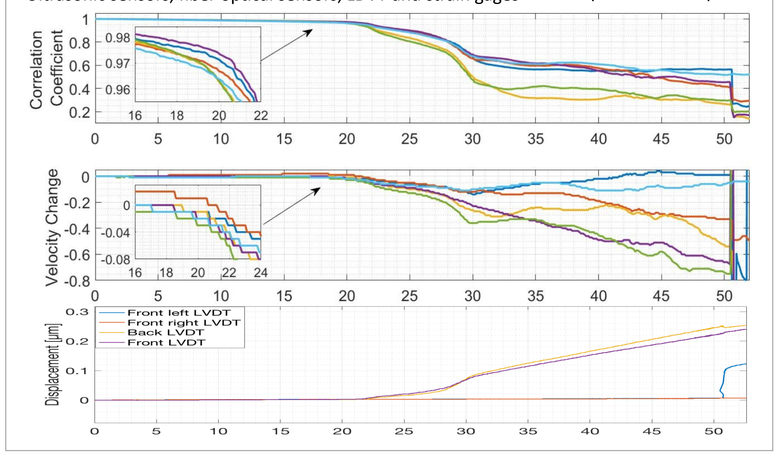
We observe the different steps of the position of the loads. Before 37 mins, two loads are always on the right part, S13E14 changes the most however the other combinations which are in the left side of the structure change less. After 46 mins, the second load started to move along the left part, the influence on the combinations on the left part of the structure become more obvious. We consider the unusual behavior of velocity change as cracks opening.

3 points bending test in IFSTTAR



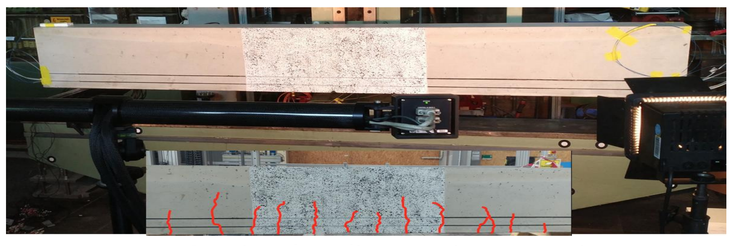
State 1:
First crack appeared :19 kN
State 2:
First crack reached top rebar : 28 kN
State 3:
Second crack appeared: 50kN
Beam separated into 2 parts

Ultrasonic sensors, fiber optical sensors, LDVT and strain gages



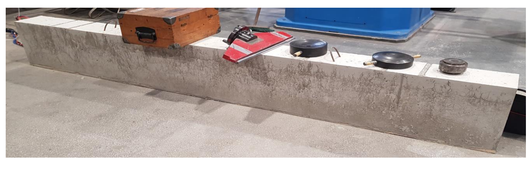
On going

4 points bending test in BAM

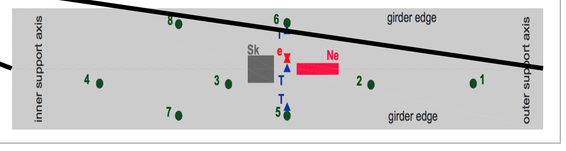


3 points bending test in Neostrain

embedded ultrasonic sensors,
two different types of strain gages
temperature sensors



Monitor real bridge – Gliwice bridge



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MARIE CURIE ACTIONS — BAM — RWTH AACHEN UNIVERSITY