SPIN
MONITORING A RESTLESS EARTH

Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

4.2 Nonlinear seismology meets Structural Health Monitoring

Vibration-Based Methods

Marco Dominguez[1]
Celine Hadziioannou[1]
Ernst Niederleithinger[2]
Andrew Curtis[3]
[1]University of Hamburg, [2]Federal Institute for Materials Research and Testing-BAM, [3]University of Edinburgh

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Structural Health Monitoring (SHM)

- Assess the integrity, health and

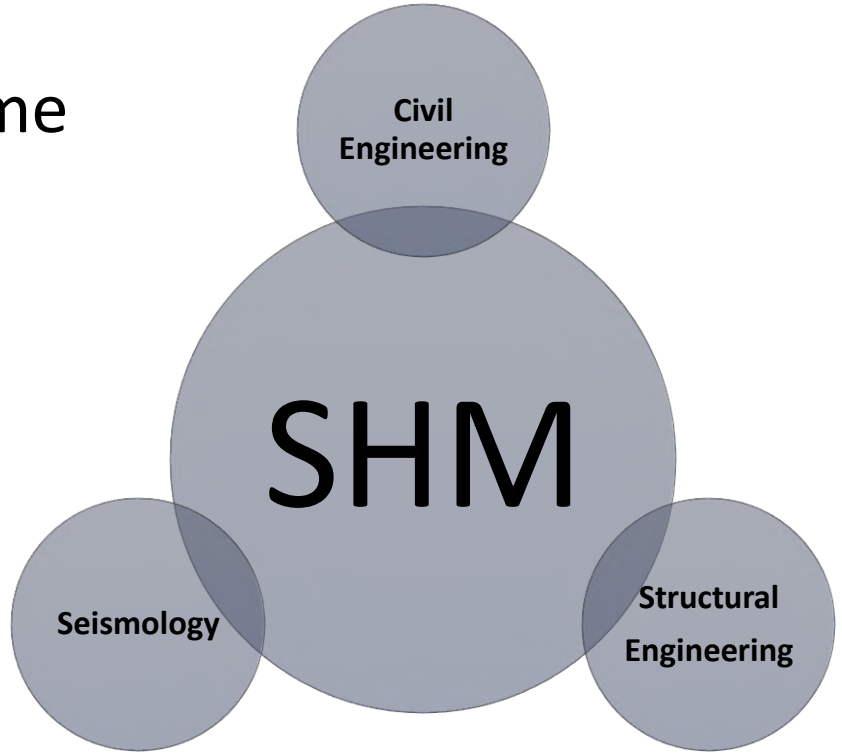
Maintenance of civil structures over the time

- It is a multidisciplinary approach

- Development of techniques:

  - Predict their failures
  - Extend their lifespan by retrofitting

    *All the structures have a design life



Why SHM is challenging

- Geometric complexity of the most real-world systems

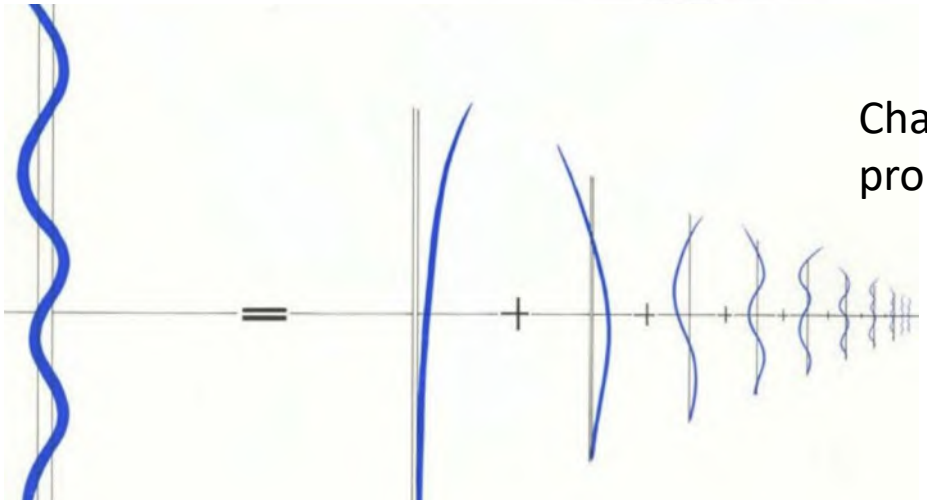
- Operational and environmental variability
  ➡ Reference structures

- Widely varying length and time scales associated with damage initiation and evolution.

SHM in different scales

Frequency domain

Modal analysis



Modal Frequencies
Modal Damping
Modal Shapes

Changes in velocity wave propagation

Ultrasound

Integrity tests in materials

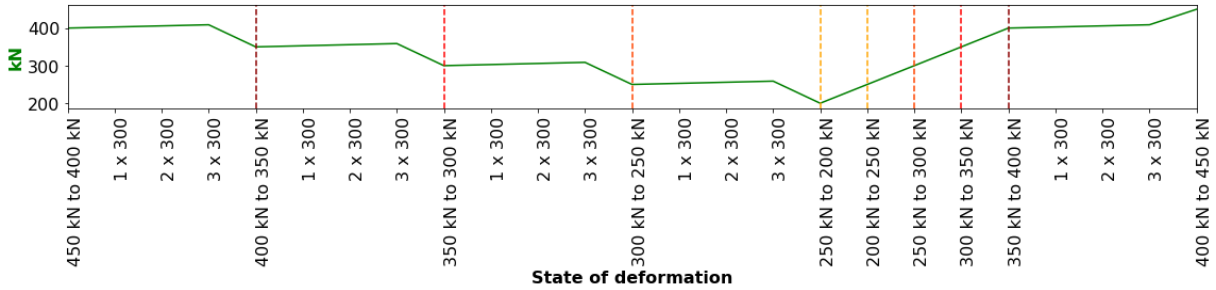
Ultrasound imaging

Take advantage of the gradient measurements.

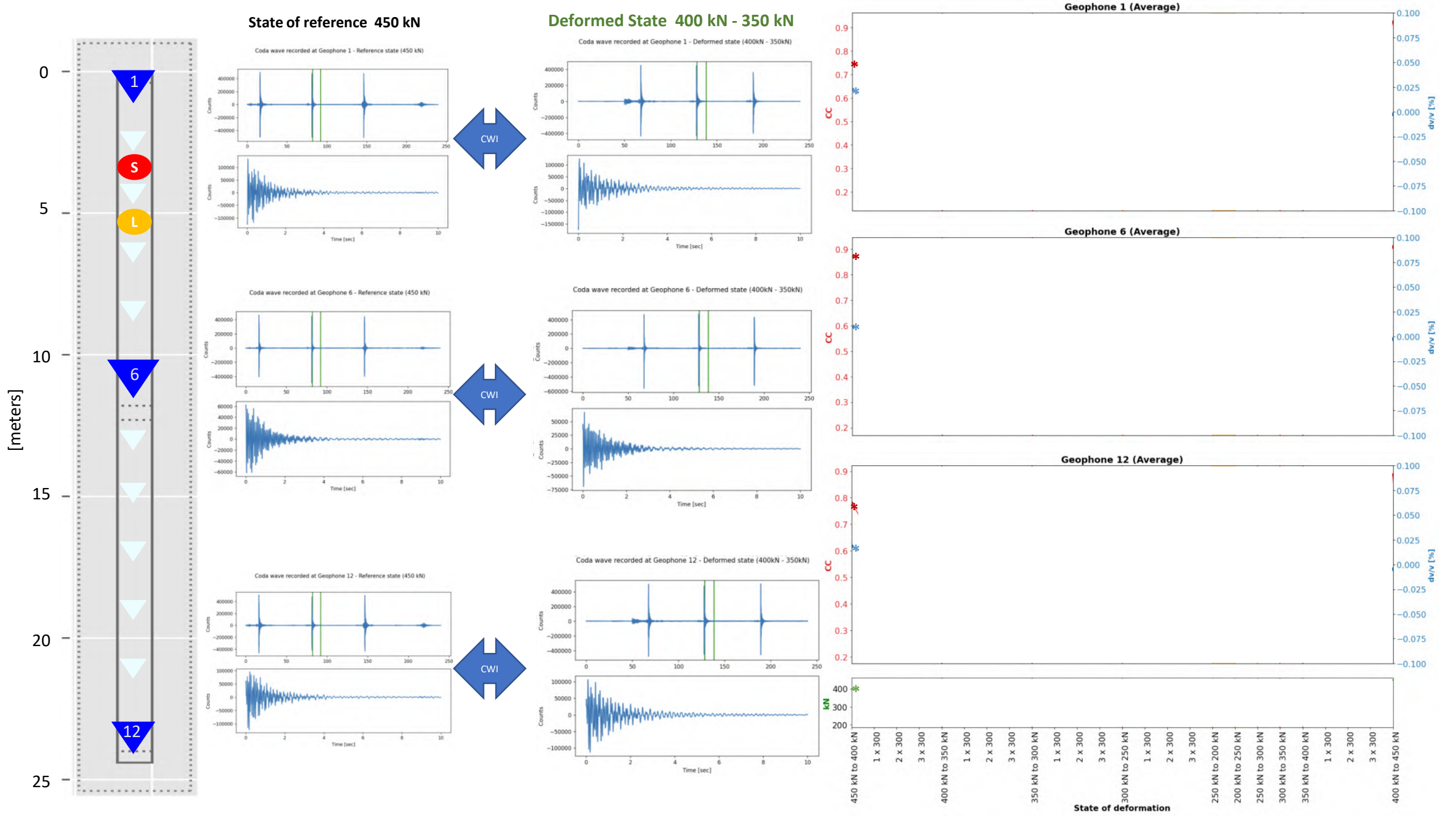
Vibration-Based Methods

- Velocity changes of a reference structure (bridge) under different stress conditions.
- Prestress process:

- Active source data
- CWI stretching method.



Preliminary results


State of reference 450 kN
Deformed State 400 kN - 350 kN
[meters]
0
5
10
15
20
25
1
S
L
6
12
Coda wave recorded at Geophone 1 - Reference state (450 kN)
Coda wave recorded at Geophone 1 - Deformed state (400kN - 350kN)
Coda wave recorded at Geophone 6 - Reference state (450 kN)
Coda wave recorded at Geophone 6 - Deformed state (400kN - 350kN)
Coda wave recorded at Geophone 12 - Reference state (450 kN)
Coda wave recorded at Geophone 12 - Deformed state (400kN - 350kN)
CWI
Counts
Time [sec]
Geophone 1 (Average)
Geophone 6 (Average)
Geophone 12 (Average)
CC
dv/v [%]
kN
450 kN to 400 kN
1 x 300
2 x 300
3 x 300
400 kN to 350 kN
350 kN to 300 kN
300 kN to 250 kN
250 kN to 200 kN
200 kN to 250 kN
250 kN to 300 kN
300 kN to 350 kN
350 kN to 400 kN
400 kN to 450 kN
State of deformation

Questions from my side

- Scattering process at material scale in a finite media.
- Explore the scope of the cutting-edge seismic instruments in this area.
- Which parameters of the coda wave are important? (Duration, attenuation).
- Healing process in building materials?
- If we measure the wavefield in the direction of the deformation, the results will change significantly?
- Changes in the civil-structure scale, lead to changes in the material scales? or vice-versa.

Thank you!