HORIZON 2020

UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH

TRUSS
Training in Reducing Uncertainty in Structural Safety

TRUSS – Structural Safety 1

UPC – BarcelonaTech experience on the use of Rayleigh based distributed optical fiber sensors for SHM of concrete structures

ESREL 2017
JUNE 18-22
PORTOROŽ
SLOVENIA

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ESREL 2017, 20th June 2017

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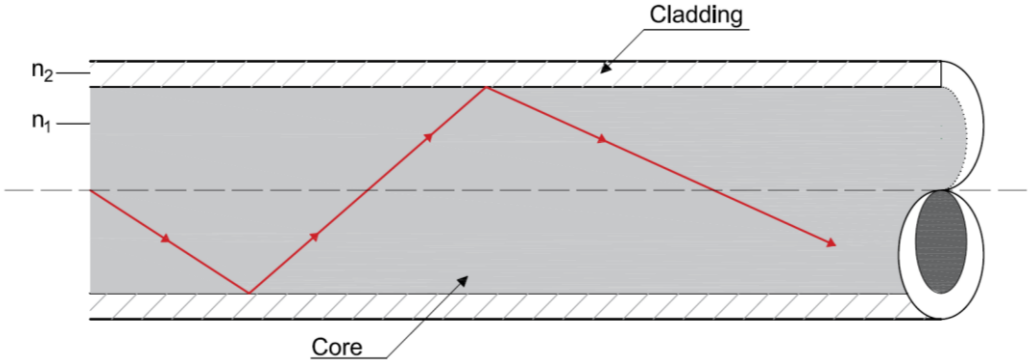
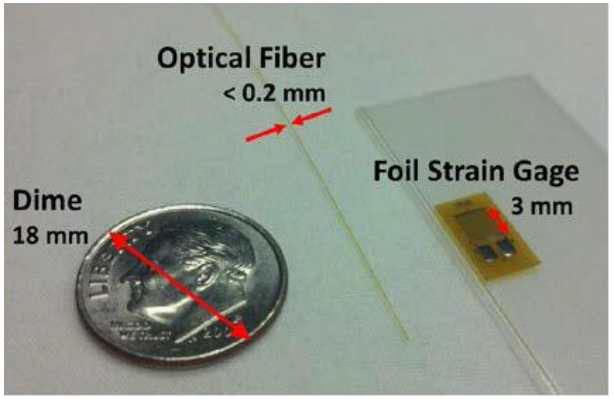
Outline

- Introduction
- Distributed Optical Fiber Sensors (DOFS)
- Laboratory Experiment with embedded DOFS
- Conclusions

Introduction – Fiber Optic Sensors

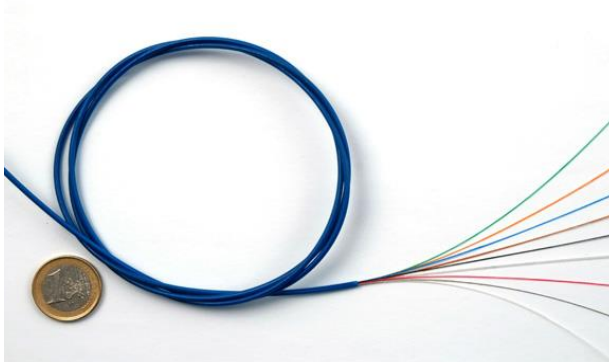




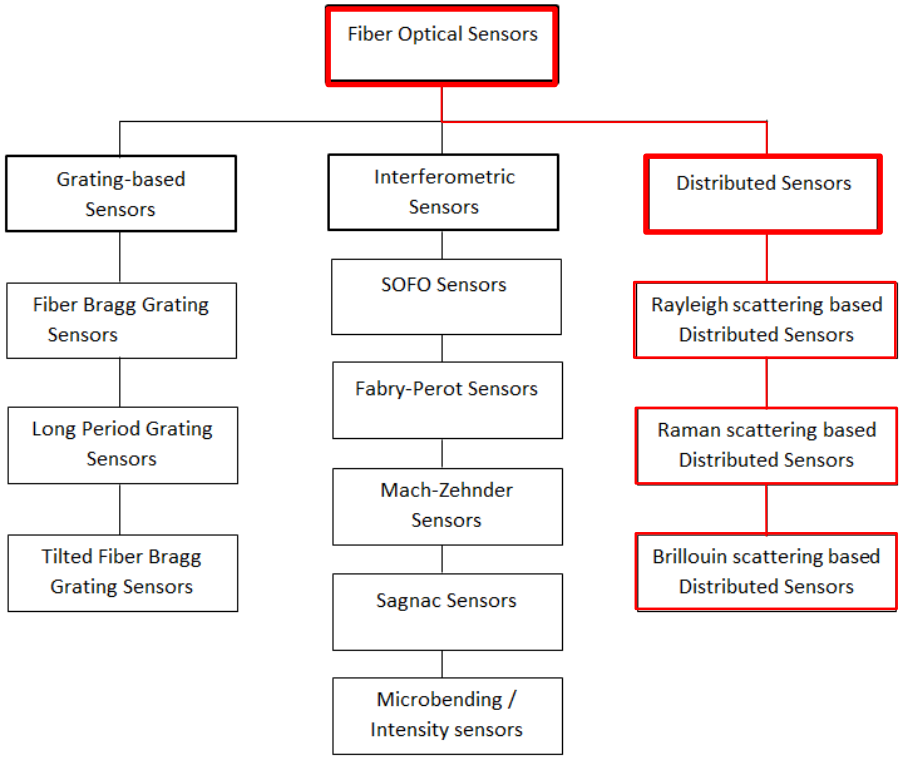
Cylindrical symmetric structure that is composed by a central "core" with a **diameter** between **4** and **600 µm** and a uniform refractive index

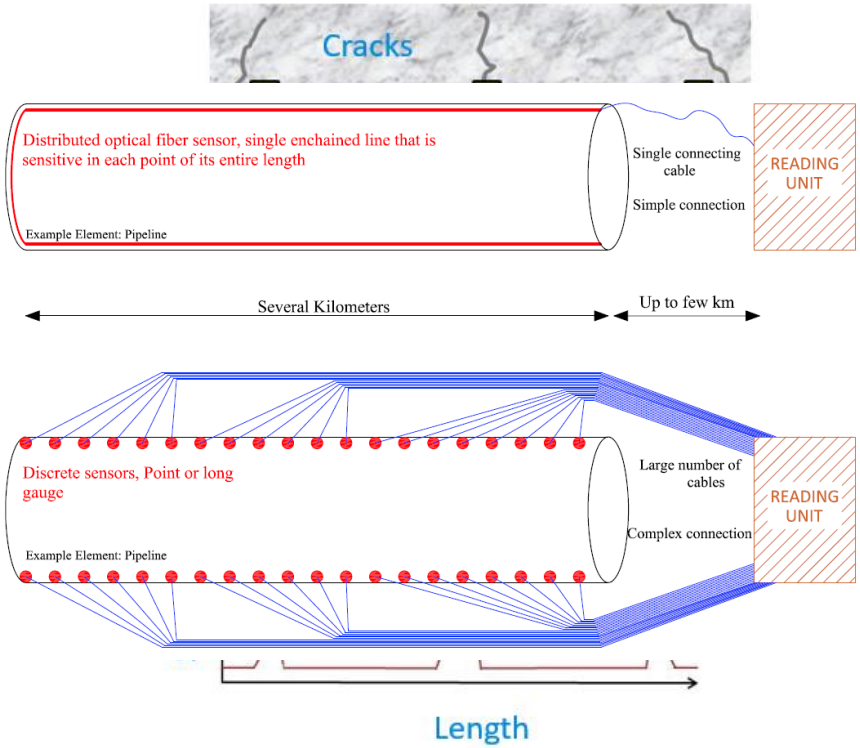
Advantages:

- Immunity from electromagnetic interferences
- Chemically inert – free from corrosion
- Withstand high temperatures
- Small and lightweight



Introduction – Fiber Optic Sensors

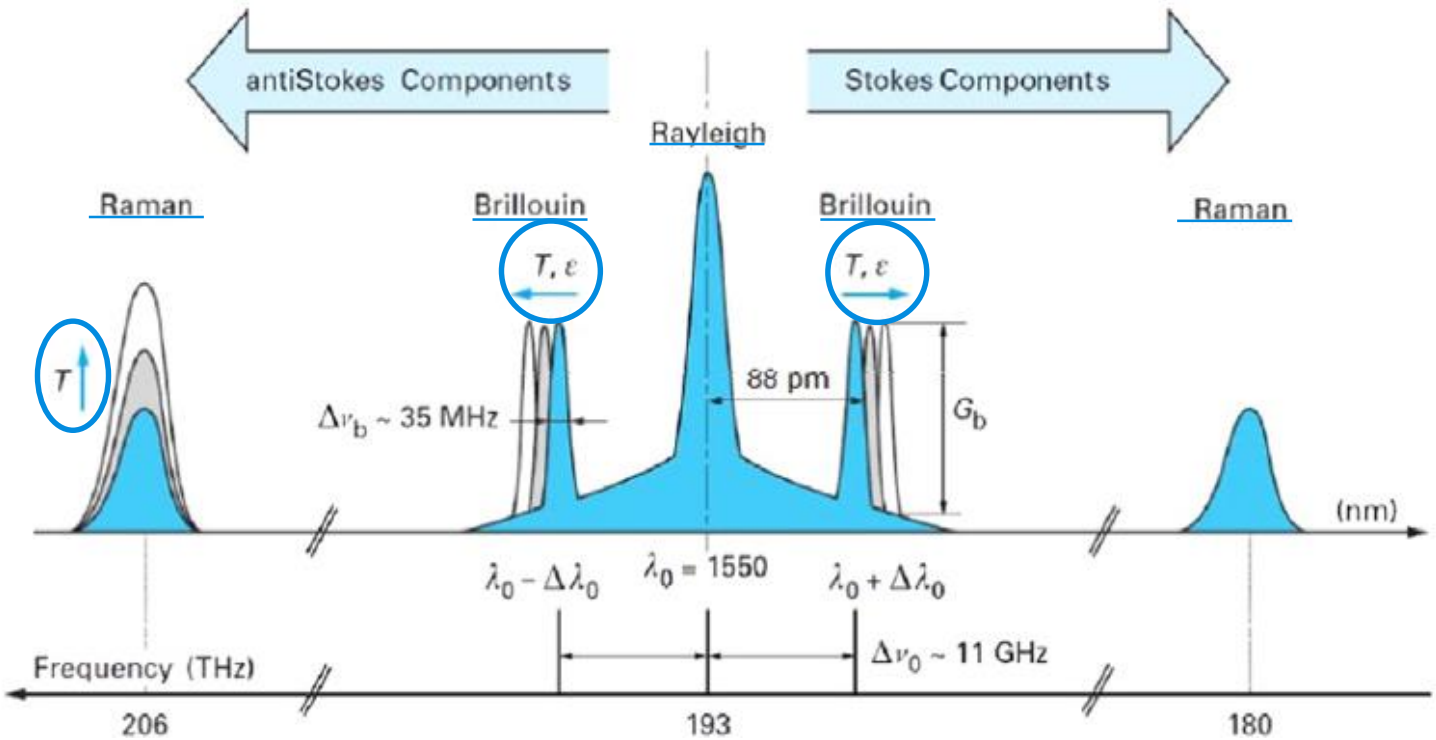




All possible crack openings are covered by the extension of the sensor

Scattering in Optical Fibers

Light backscatter provides three different components

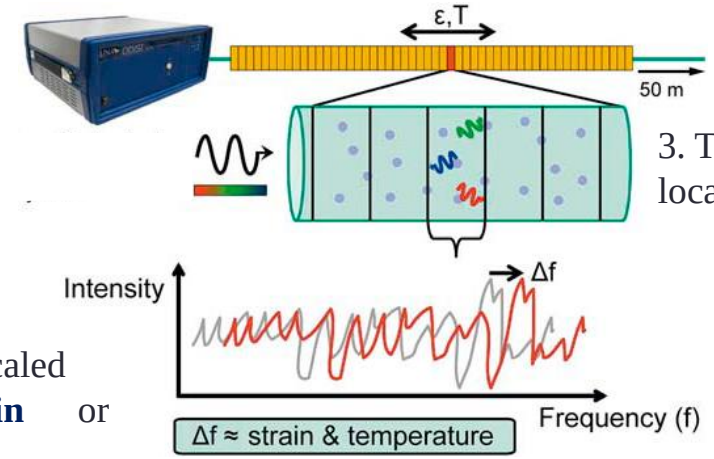


Optical Backscatter Reflectometer - OBR

1. OBR system measures the **Rayleigh backscatter** as a function of length in an optical fiber with high spatial resolution **(1mm)**

Swept wavelength interferometry (fiber is divided in small windows)

2. External stimulus



3. Temporal and spectral shifts in the local backscattered pattern

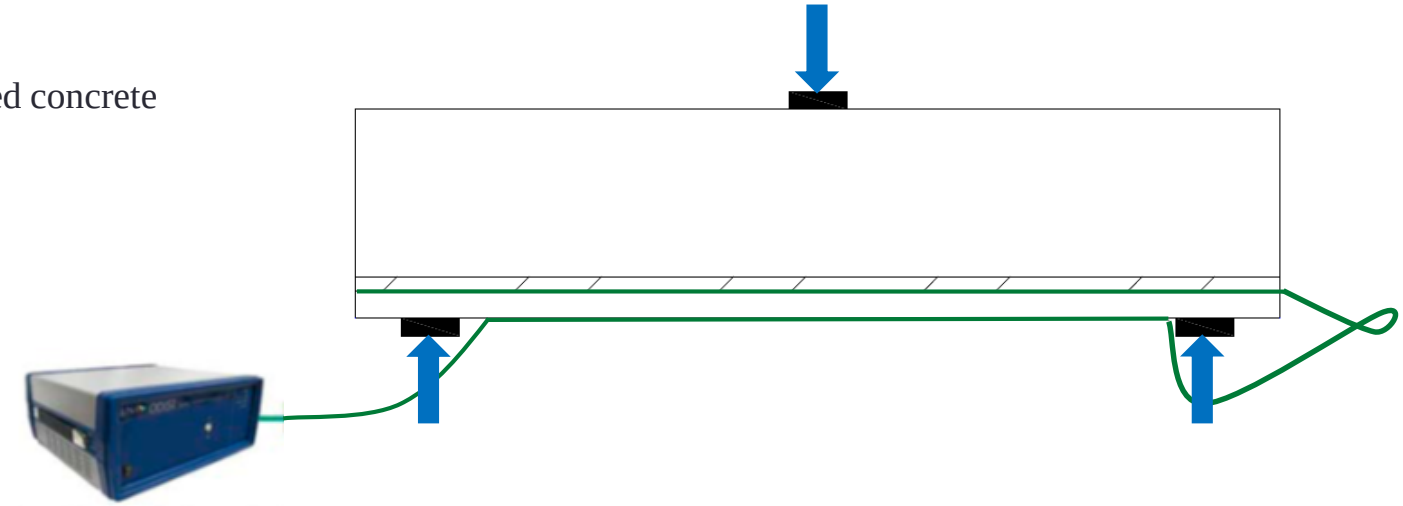
4. Shifts can be measured and scaled to give distributed **strain** or **temperature** measurements

- Short range (50-70 m)
- High spatial resolution (1 mm)

Laboratory test with embedded DOFS

Two small reinforced concrete beams load test:

100x180x800 [mm]



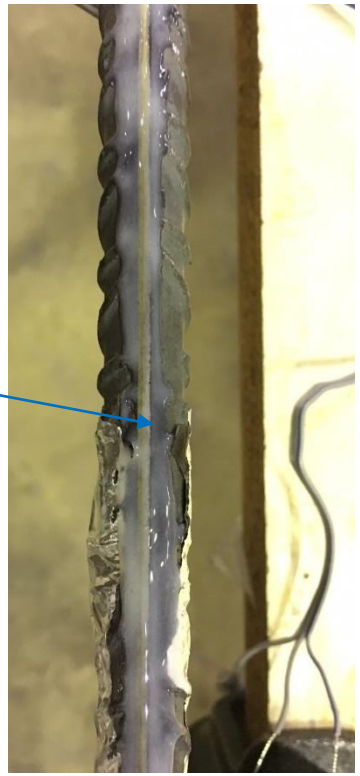
Main objectives:

- Feasibility of installation of DOFS directly on rebar element of reinforced concrete beam
- Comparison of strain measured at rebar and surface of the concrete
- Detect and locate damage (cracks) induced by bending moment

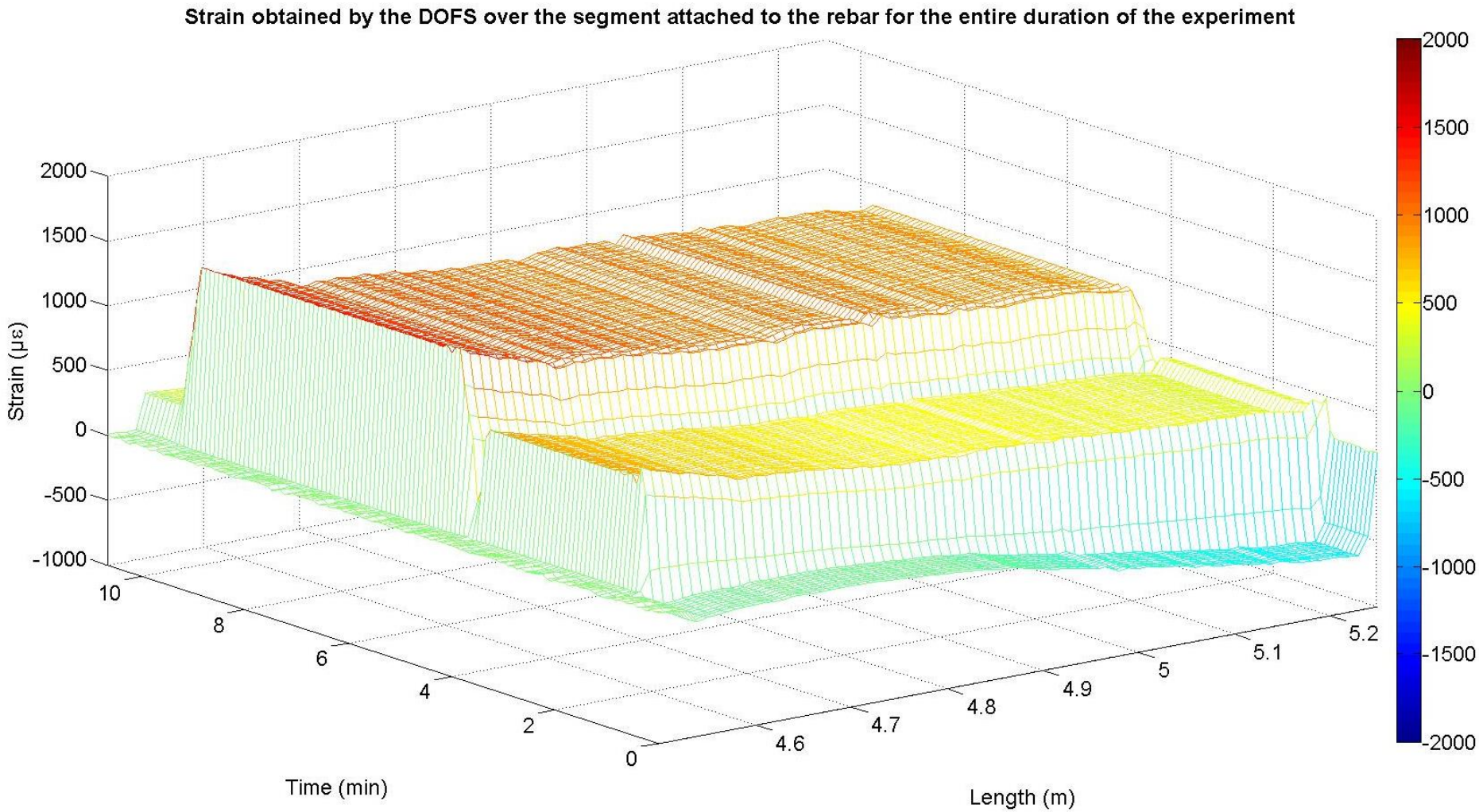
Laboratory test with embedded DOFS

Rebar tensile test

DOFS attached to the rebar



Laboratory test with embedded DOFS



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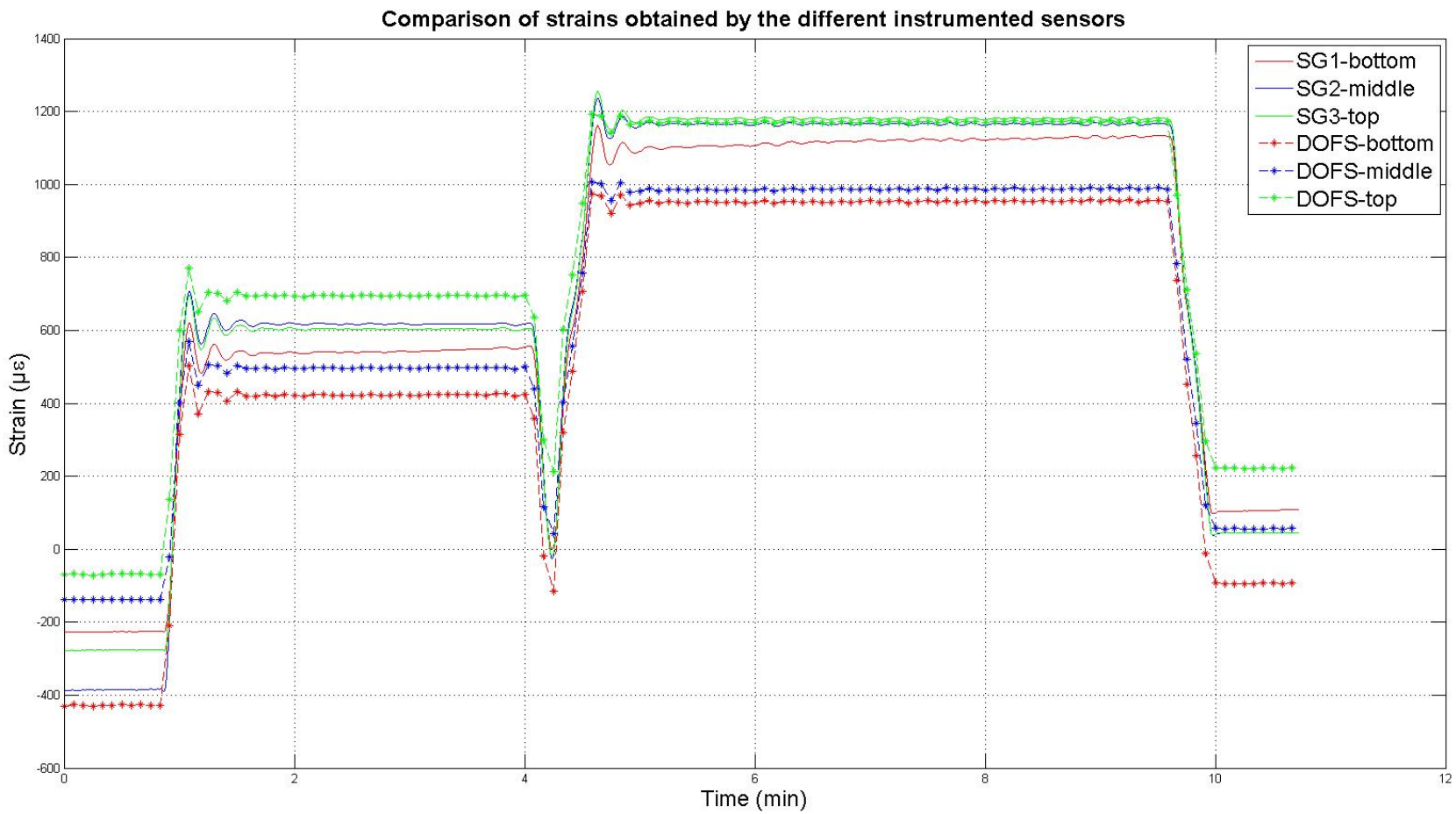

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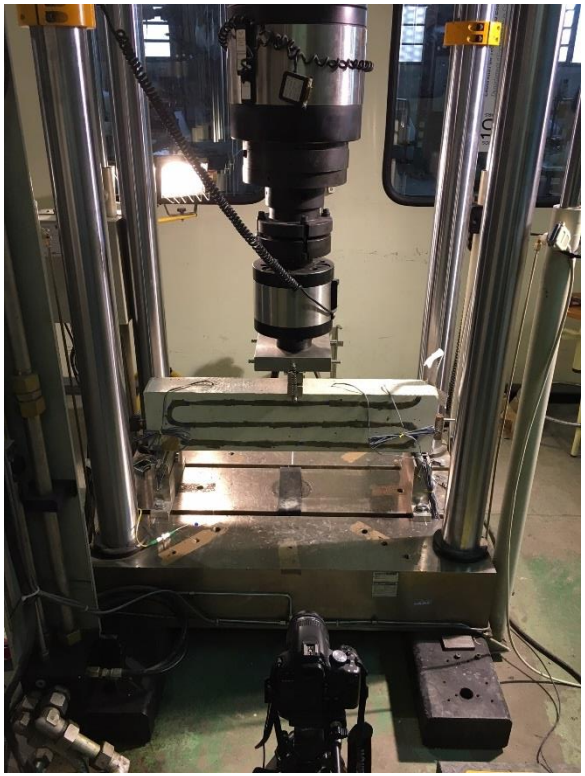
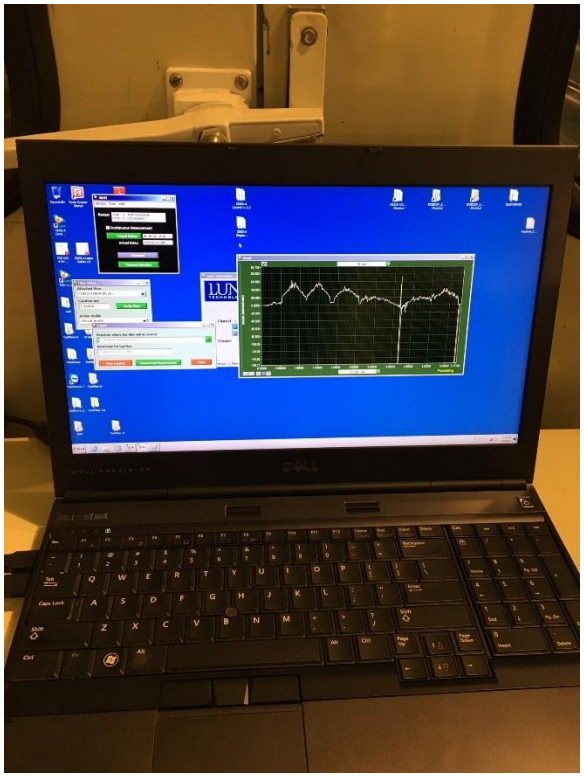




Beam 1

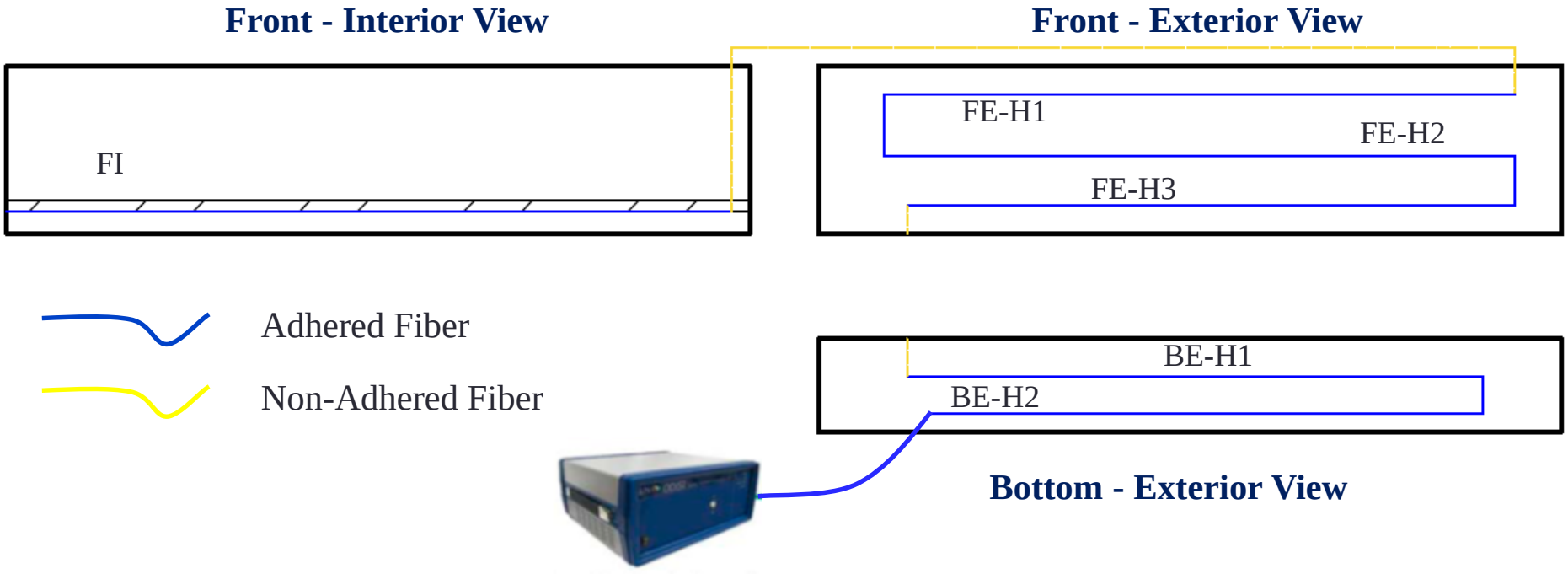
Beam 2

Laboratory test with embedded DOFS

Beam 1 - Cyanoacrylate

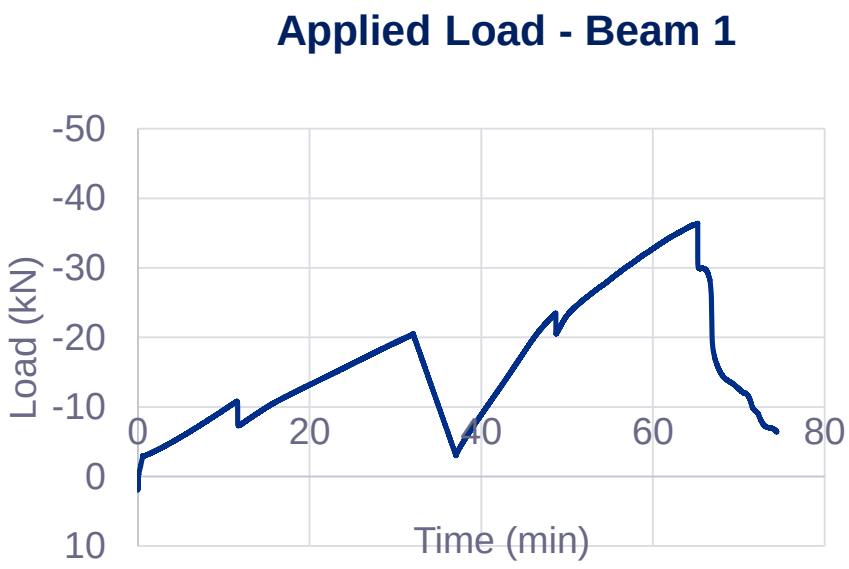
Beam 2 – Two-component epoxy

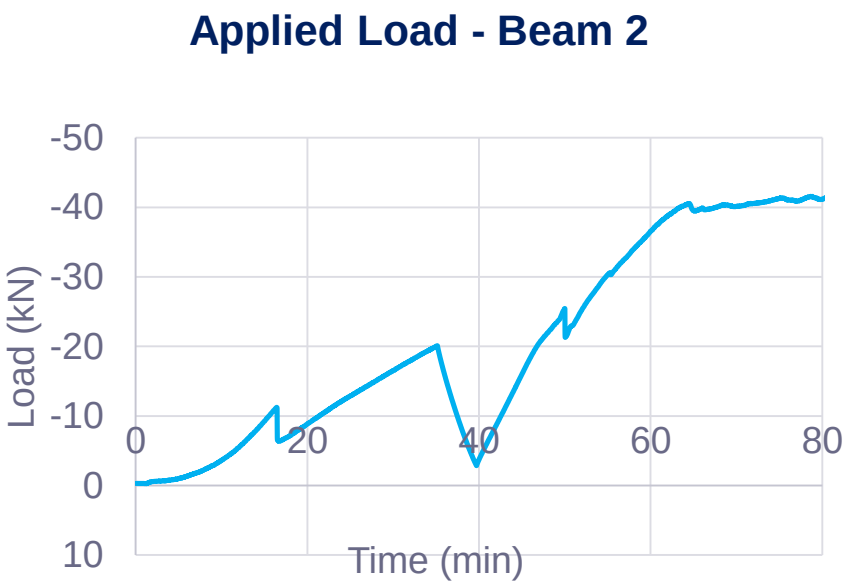
Laboratory test with embedded DOFS



FI – Front Interior
FE-H(n) – Front Exterior Horizontal
BE-H(n) – Bottom Exterior Horizontal

Laboratory test with embedded DOFS





Laboratory test with embedded DOFS

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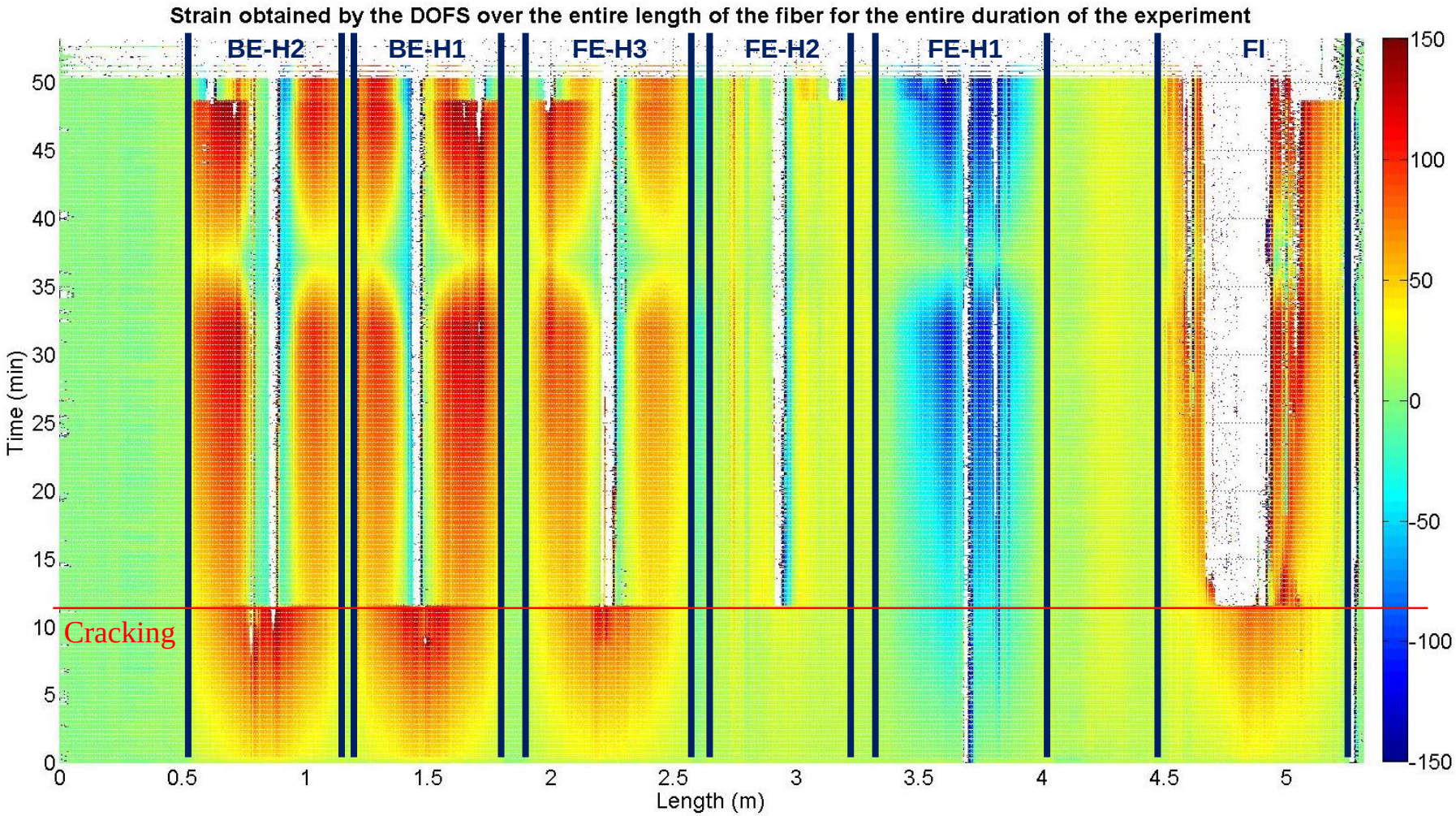
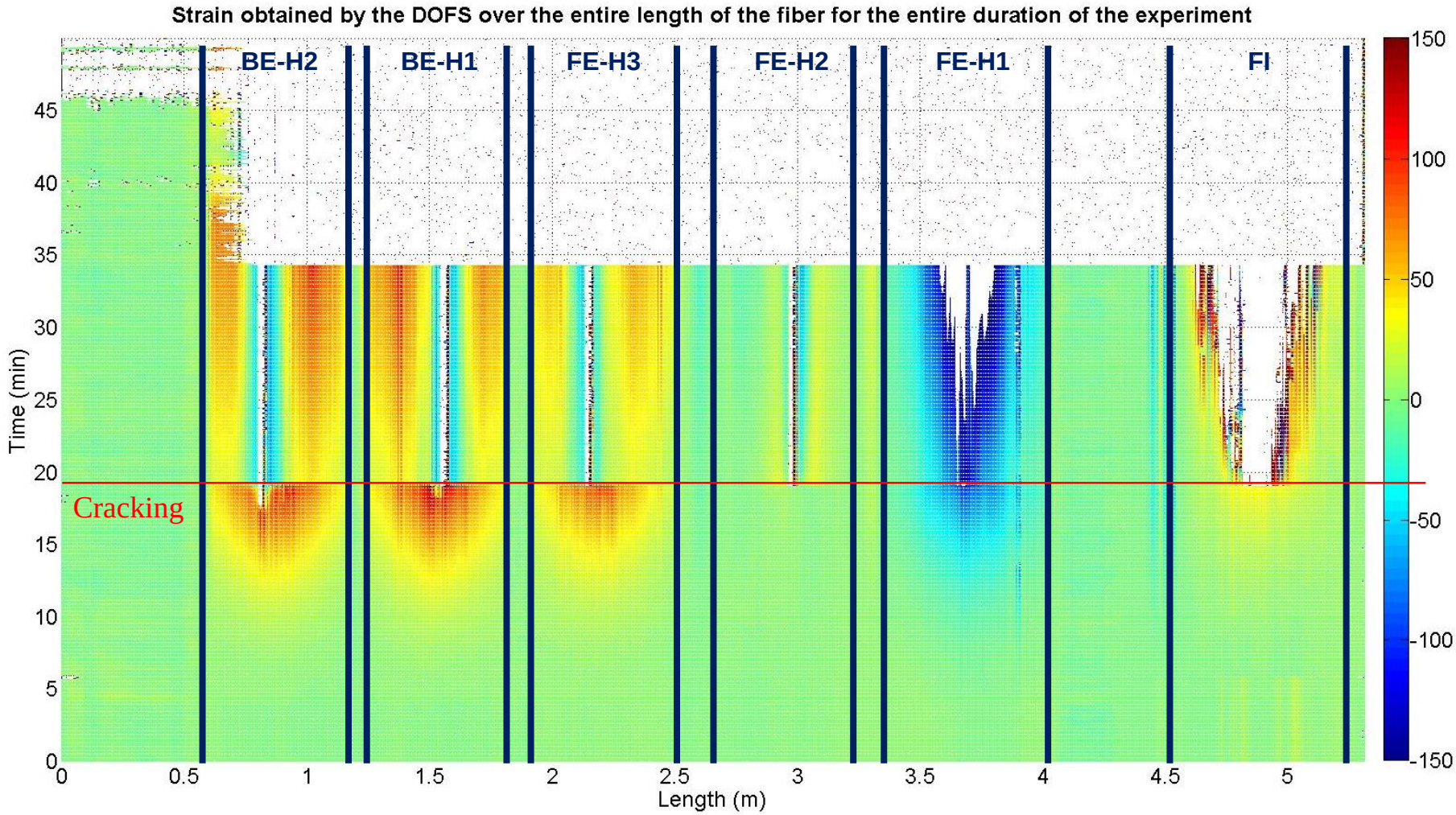


Laboratory test with embedded DOFS

Beam 2



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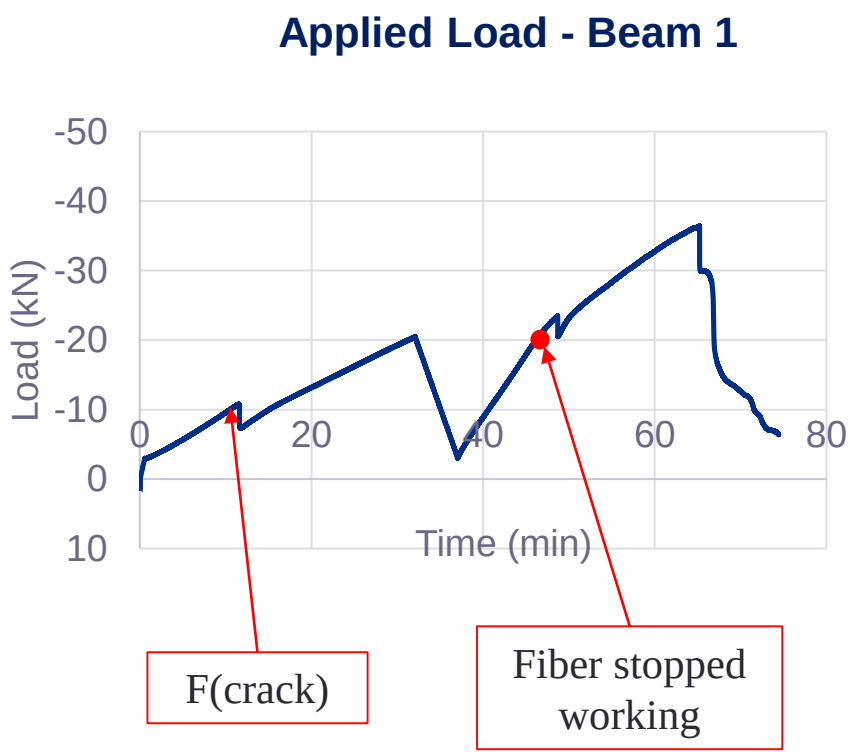

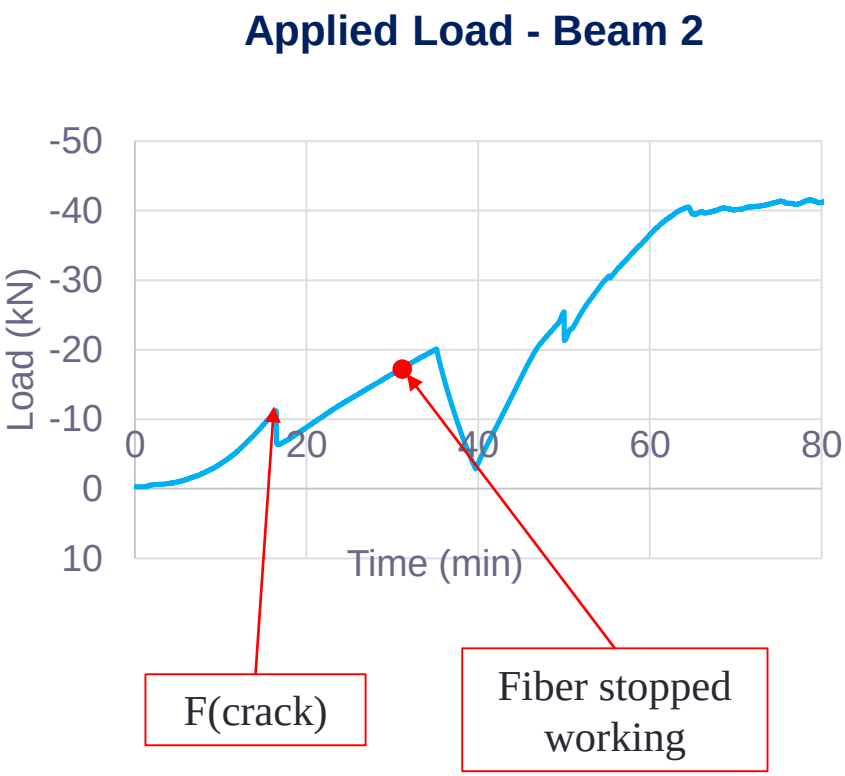

Laboratory test with embedded DOFS

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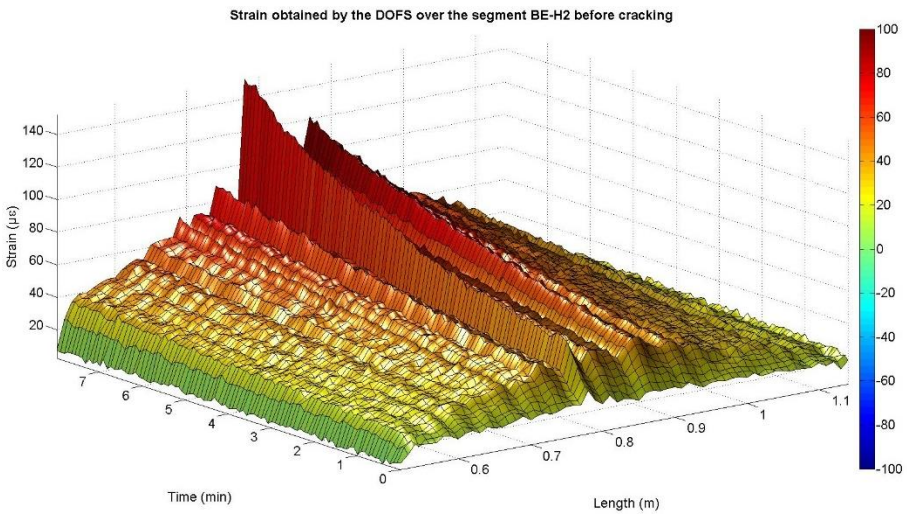
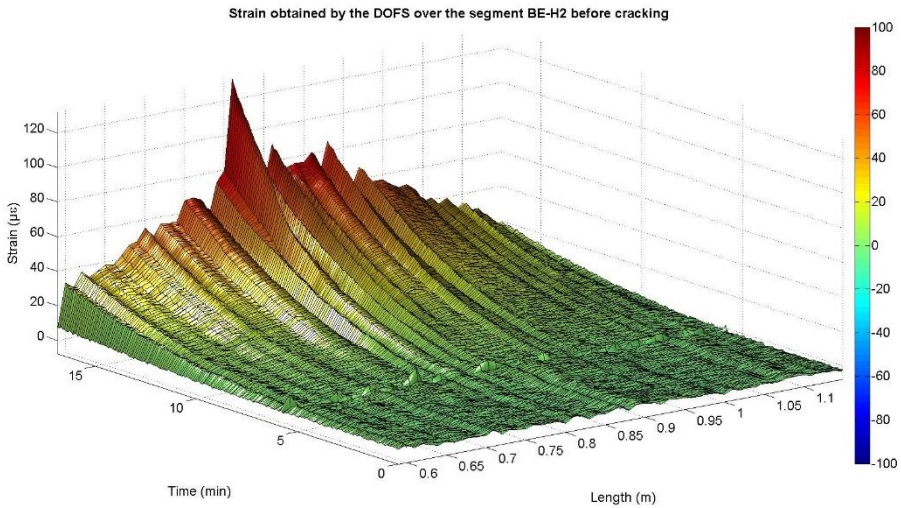


BEAM 2



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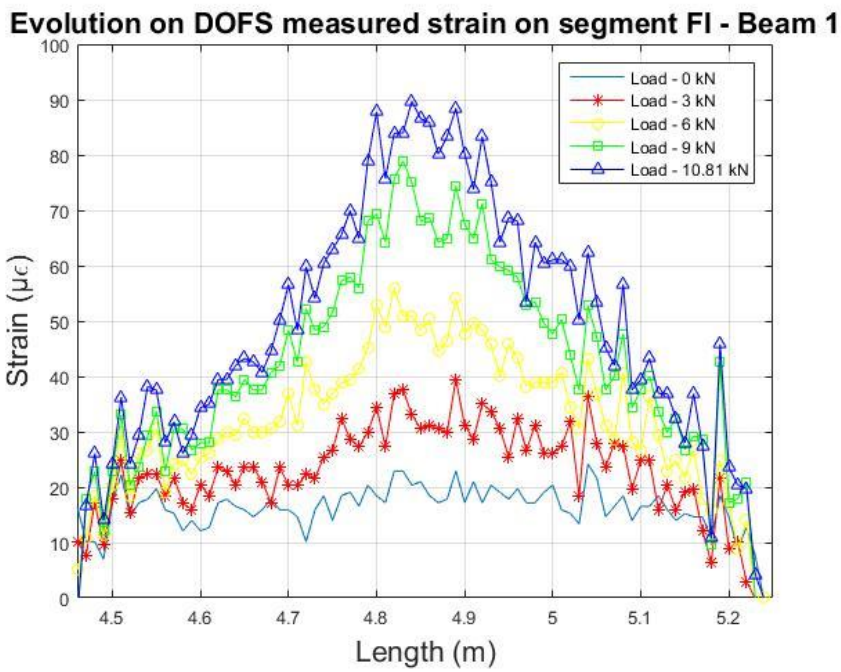

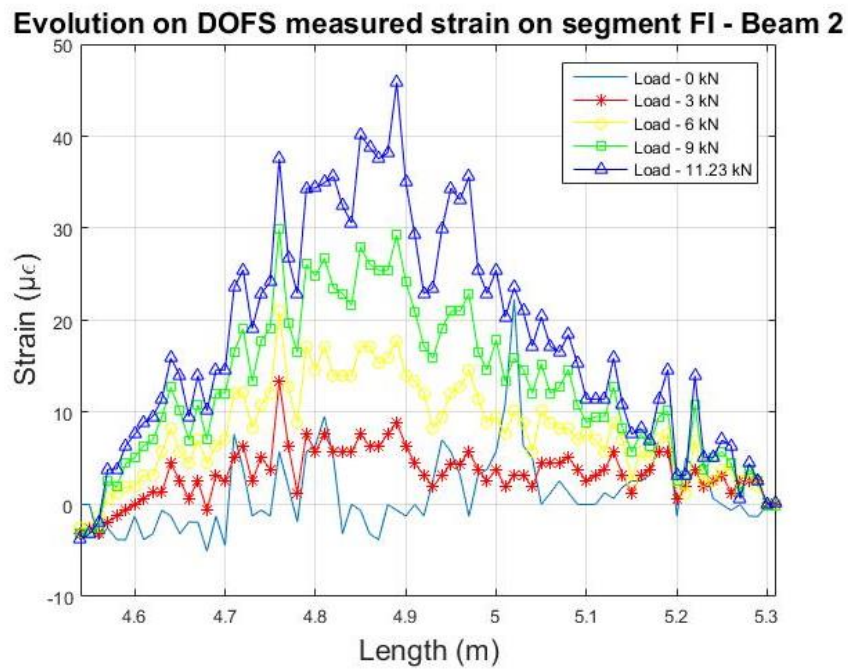

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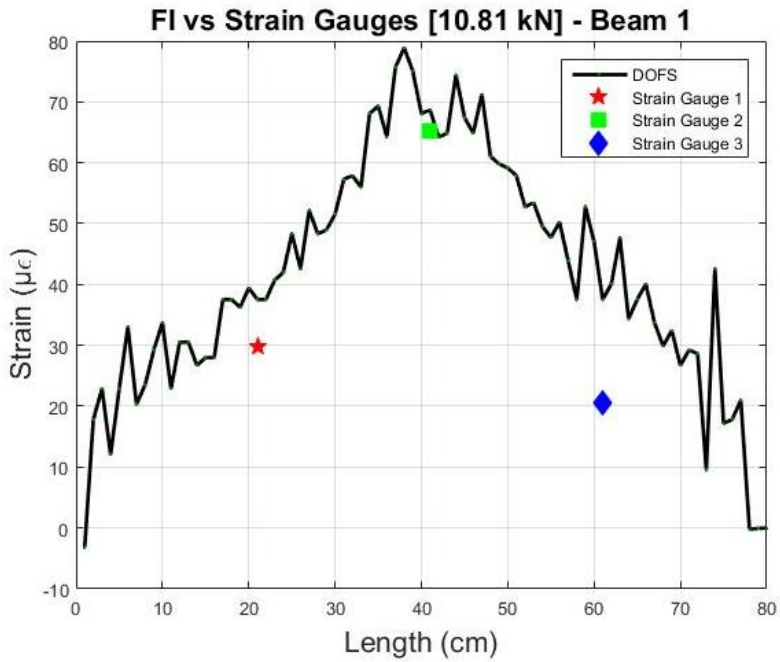

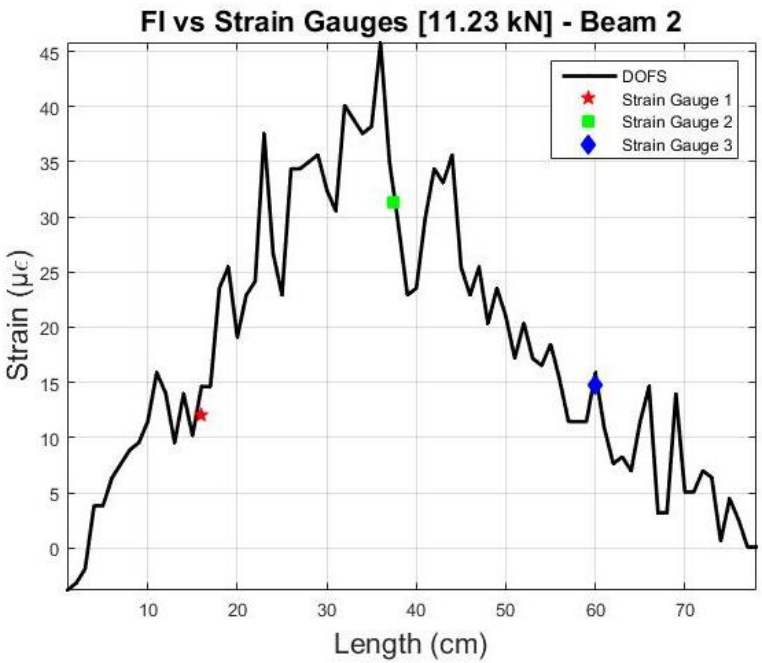

Conclusions

- Proven feasibility of implementing an optical fiber with minimal coating directly to a embedded rebar element;
- Proven feasibility on the detection and location of damage with this implementation technique;
- Possibility of simultaneously measuring a large number of structural points with the use of a single sensor;
- Fairly good agreement of the optical fiber data when compared with the strain gauges;
- Poor performance of the optical fiber after the occurrence of damage in the location of the crack, specially in its embedded segment;

Future work:

- Analysis of different adhesives and bonding mechanisms between the fiber and the structure.
- Study of the long-term reliability of this technology on concrete structures

THANK YOU!

Questions?

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