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Siltatekniikan päivät

Smart Technology and Monitoring of Post-Tensioning systems

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Georg Schoth

Project Engineer RnD

Education

- 2018 – 2021 Master of Science (M.Sc.) | Mechanical Engineering
  Technische Universität Bergbauakademie Freiberg
- 2014 – 2018 Bachelor of Science (B.Sc.) | Mechanical Engineering
  Technische Universität Bergbauakademie Freiberg

Work (4 Years with DYWIDAG)

- 2022 – pres. RnD, Structural Health Monitoring (SHM)
- 2021 – 2022 RnD, Robotic Inspection and Maintenance (RIM)

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Structural Health Monitoring

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DYWIDAG Bridge Lifespan Management capabilities

Inspection

- Visual:
  - Cap removal, Endoscopic Inspection, Ultrasonic Inspection
  - By rope access
- Lift-Off Test
- Hammer tapping
- Vibration Measurements
  - Force & Damping
- Robotic inspection:
  - Magneto Inductive inspection
  - Visual Inspection

Structural Health Monitoring

- Sensor agnostic remotely operated data acquisition and computing system
- Products
  - Accelerometer (incl. Seismic)
  - Force measurement free length (e.g. fibre optics) or at anchorages (DYNA Force)
  - GNSS, Strain, Weather
  - Edge computing, data storage & shared API
- Data analysis
  - Automated Reporting
  - Cable Force Calculation
  - Threshold based alerting

Maintenance, Repair & Retrofitting

- Cable replacement
- Cable surface repair and enhancement
- Corrosion protection tape Cableskin® automated Wrapping
- Cable Cleaning
- PE-Welding
- Damper replacement
- Fire protection installation

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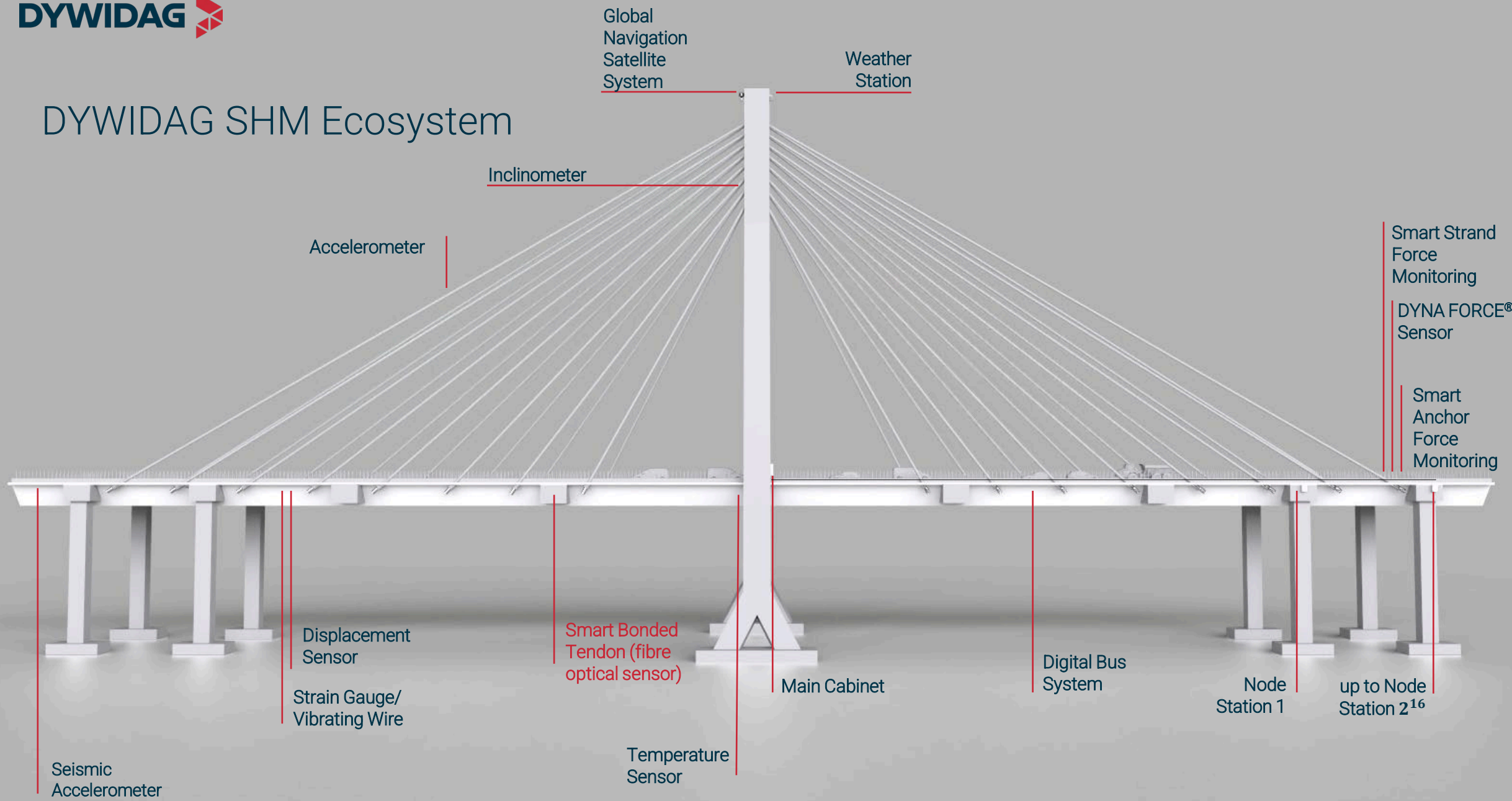
DYWIDAG SHM Ecosystem



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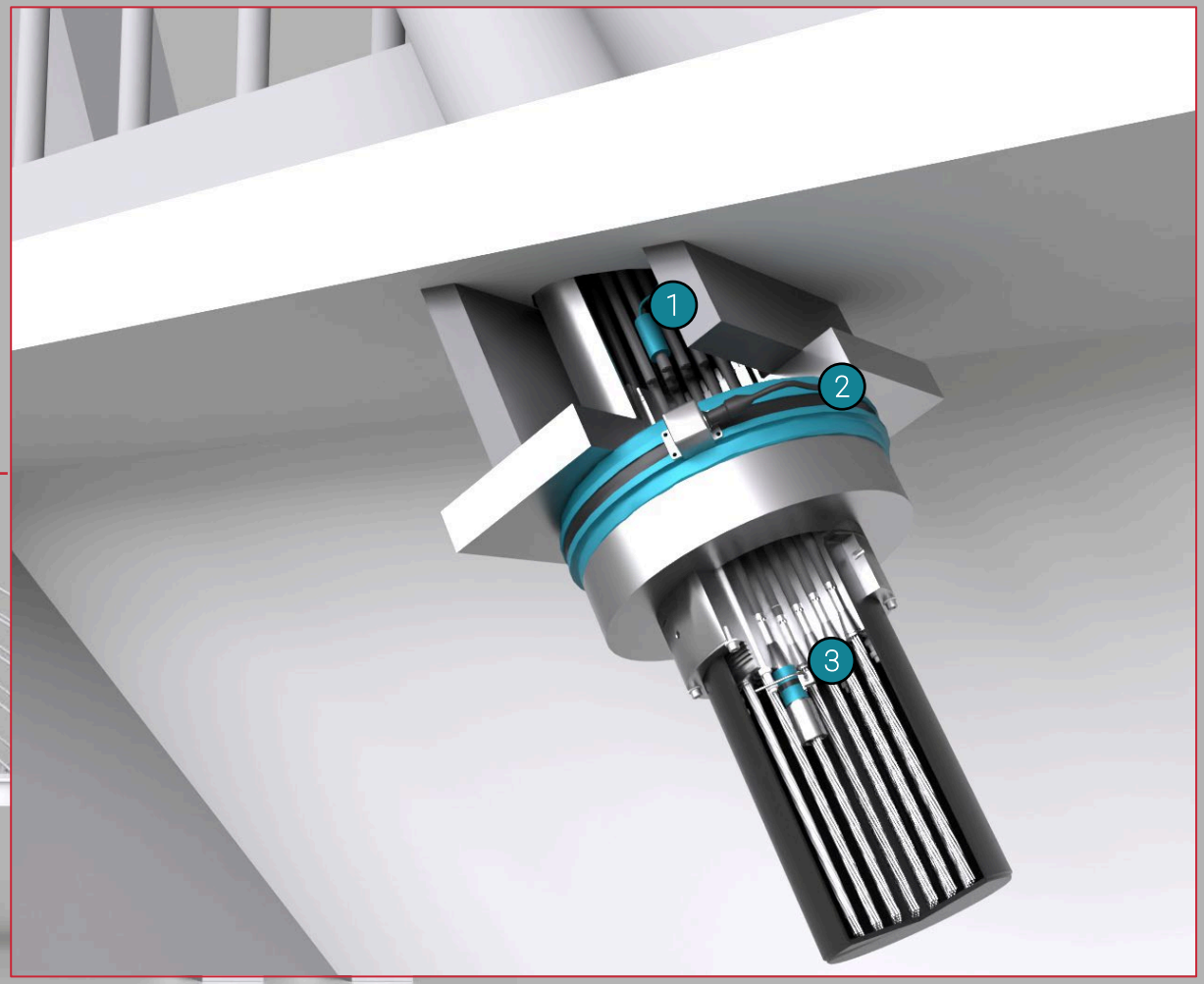
Anchorage Force Monitoring



1 - Dyna Force® Sensor

Measurement method	Magnetoelastic sensors
Nominal load	300 - 12000 kN
Operation temperature	0 up to +45 °C
Accuracy	±1%

2 - Smart Anchor

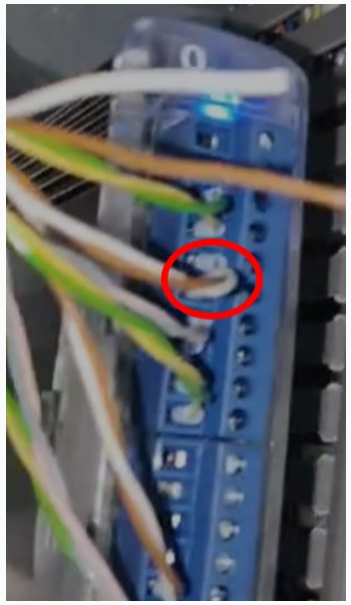
Measurement method	Compression method
Nominal load	500 - 10000 kN
Overload	120%
Operation temperature	-40 up to +80 °C
Accuracy	±1% (at min. 50% FS)

3 - Smart Strand

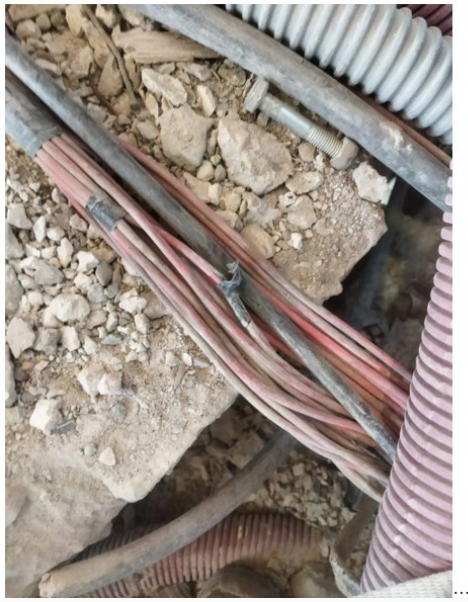
Measurement method	Compression method
Nominal load	200 kN
Overload	120%
Operation temperature	-40 up to +80 °C
Accuracy	±1% (at min. 50% FS)

SHM Systems Challenges

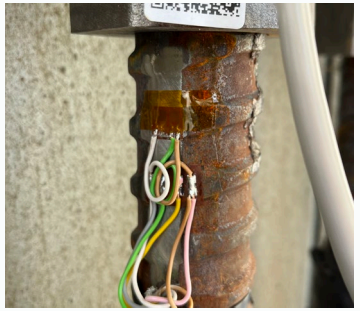
- Installation, vandalism and rodent damage
- Extreme temperatures differences (-30 to +60 °C)
- Weather exposure,
  - (UV, lightning, wind, precipitation)
- Salt water stray
- Seismic events
- Unexpected loading events
- expected Structure lifetime >> electronic lifetime



- Sensor cable not properly connected to DAQ



- Sensor cable damage due to improper cable protection



- Sensor not properly protected from environmental conditions

- Component not connected

- DAQ not properly sealed

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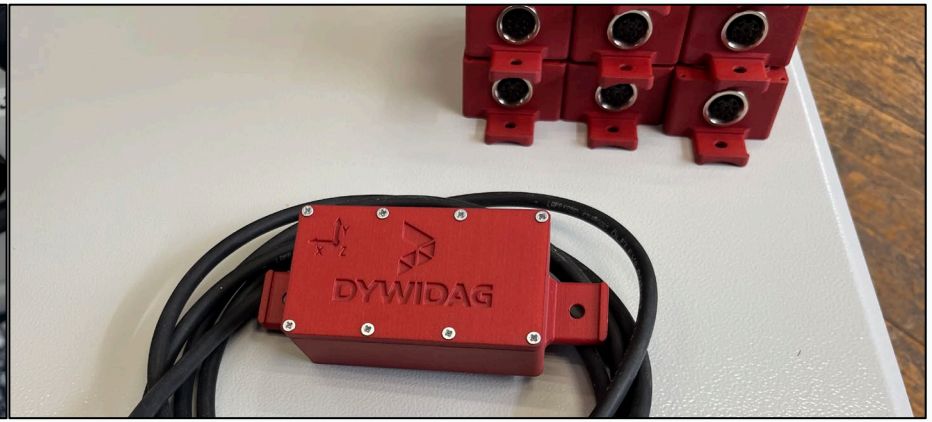
Design for durability

Component	Minimal protective requirements						
Cabinet inside (Pylon/Girder)			min. IP66 (according to IEC 60529)	Suitable corrosion protection level (levels acording to DIN EN ISO 12944)	Geolocally suitable temperature range (incl. effects of radiation on sensors or housing structure)	UPS (Uninterrupted Power Suppy)	Vibration resistance
Sensor inside (Pylon/Girder/Stay)							
Cabeling inside/exposed							
Sensor exposed (top of Pylon)	UV protection	Lightning protection					
Sensor exposed (Stay)							
Cabinet exposed							

Design for serviceability



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Smart Bonded Tendon

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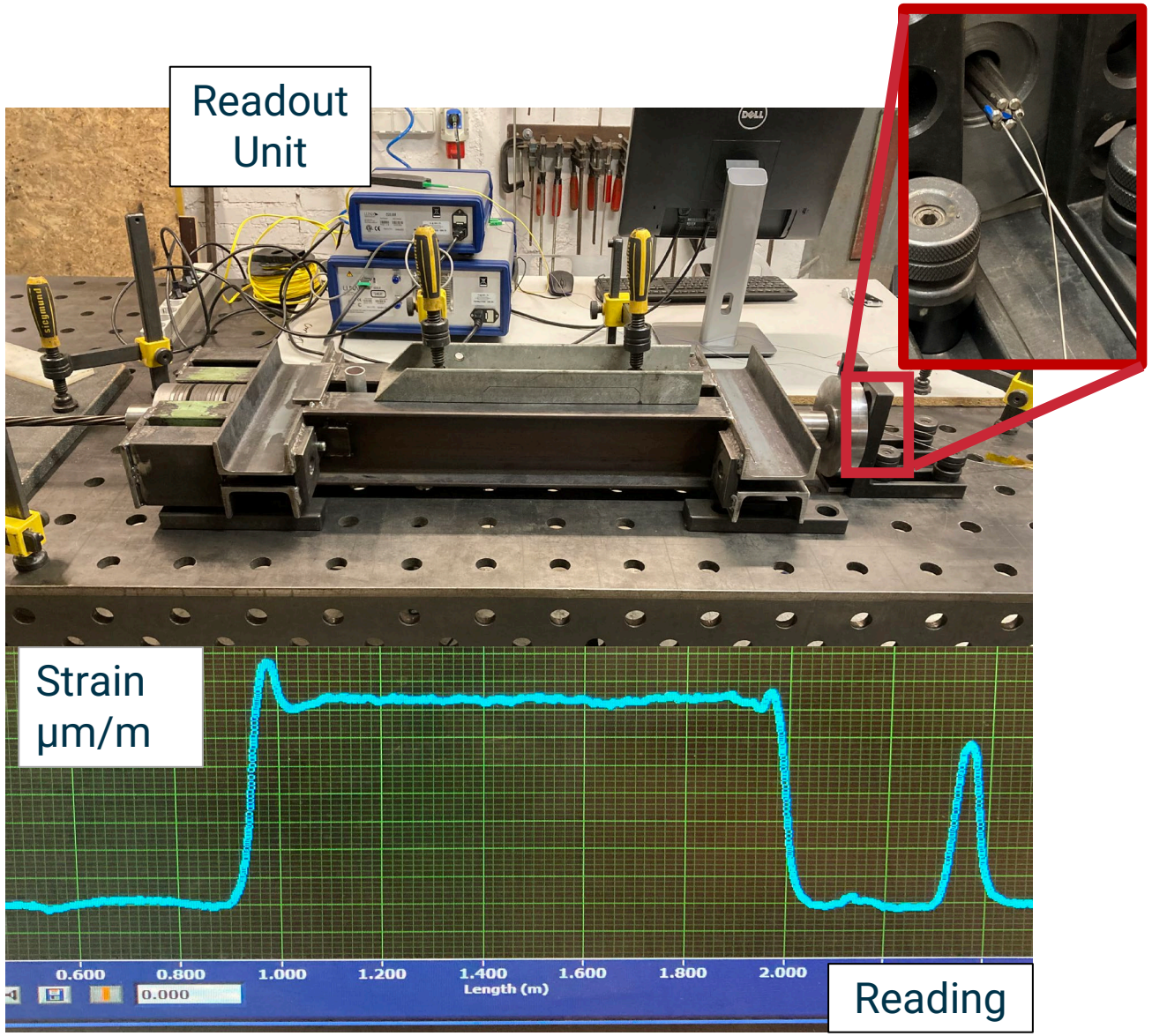
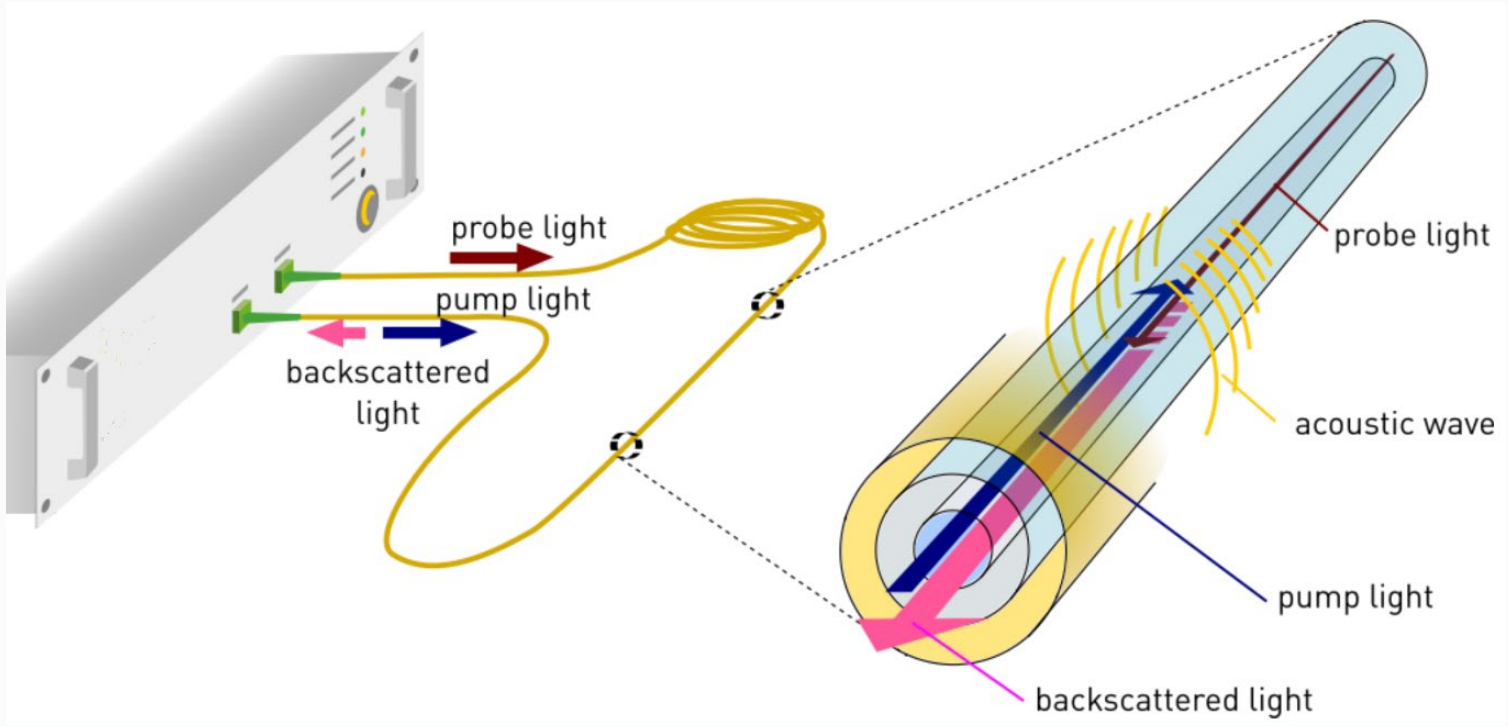
Smart Bonded Tendon

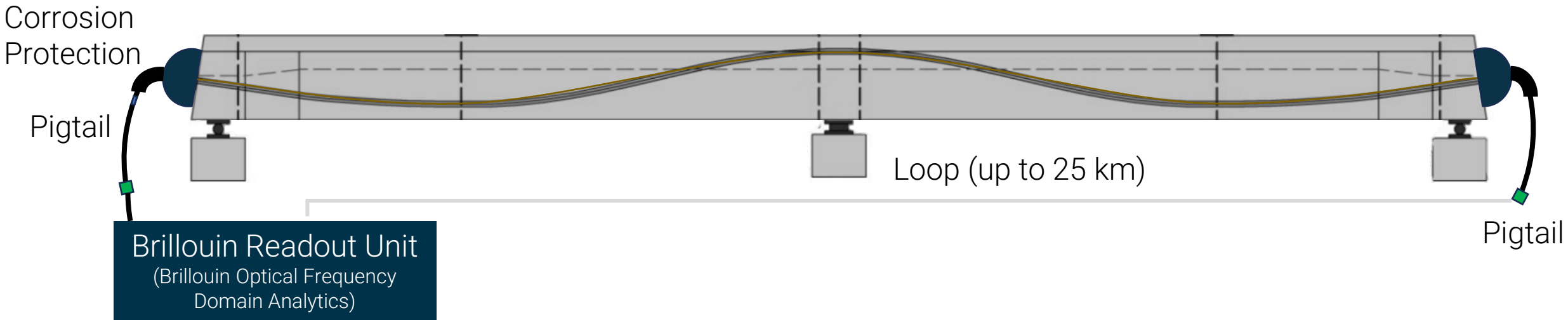
- **Smart Tendon** is sensor (+assembly) technology integrated in (bonded) strand tendons (PT & GT applications)
- Fiber optical sensors are used to determinate
  - Location **of local defects**
  - Longitudinal **variation of friction losses**
  - **Local stress variation** in the tendons due to life loads
  - **Local voids** in the grouting of the bonded tendon (> 100 mm)
  - **Local stress peaks** due to cracking of the concrete
- fiber optical sensors can detect and locate **failures along the entire tendon path**



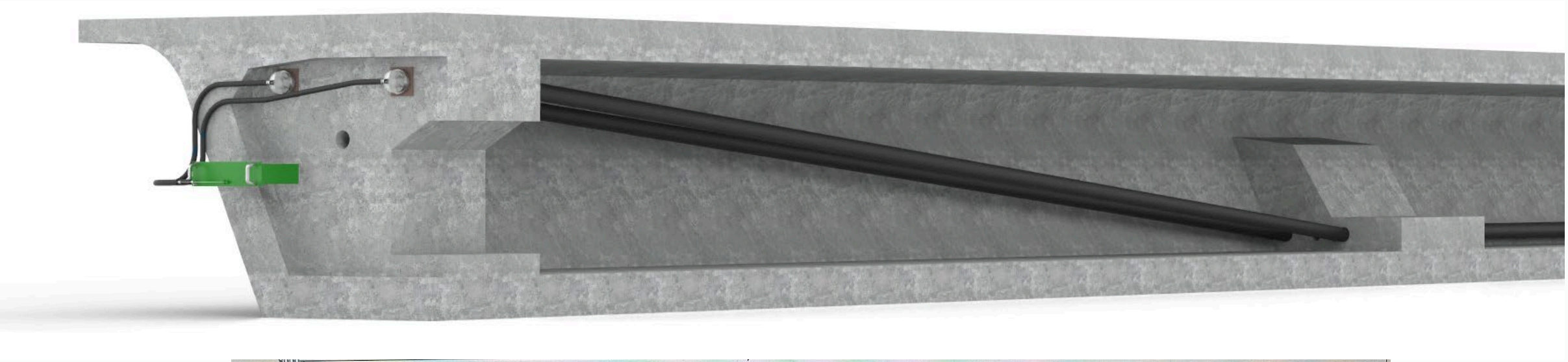


- Fiber In Metal Tube (FIMT) fitted within the “cavity circle”
- sensor transmits force purely based on friction.

Smart Bonded Tendon – Single Sensor Layout & Readout



Smart Bonded Tendon – Double Sensor Layout



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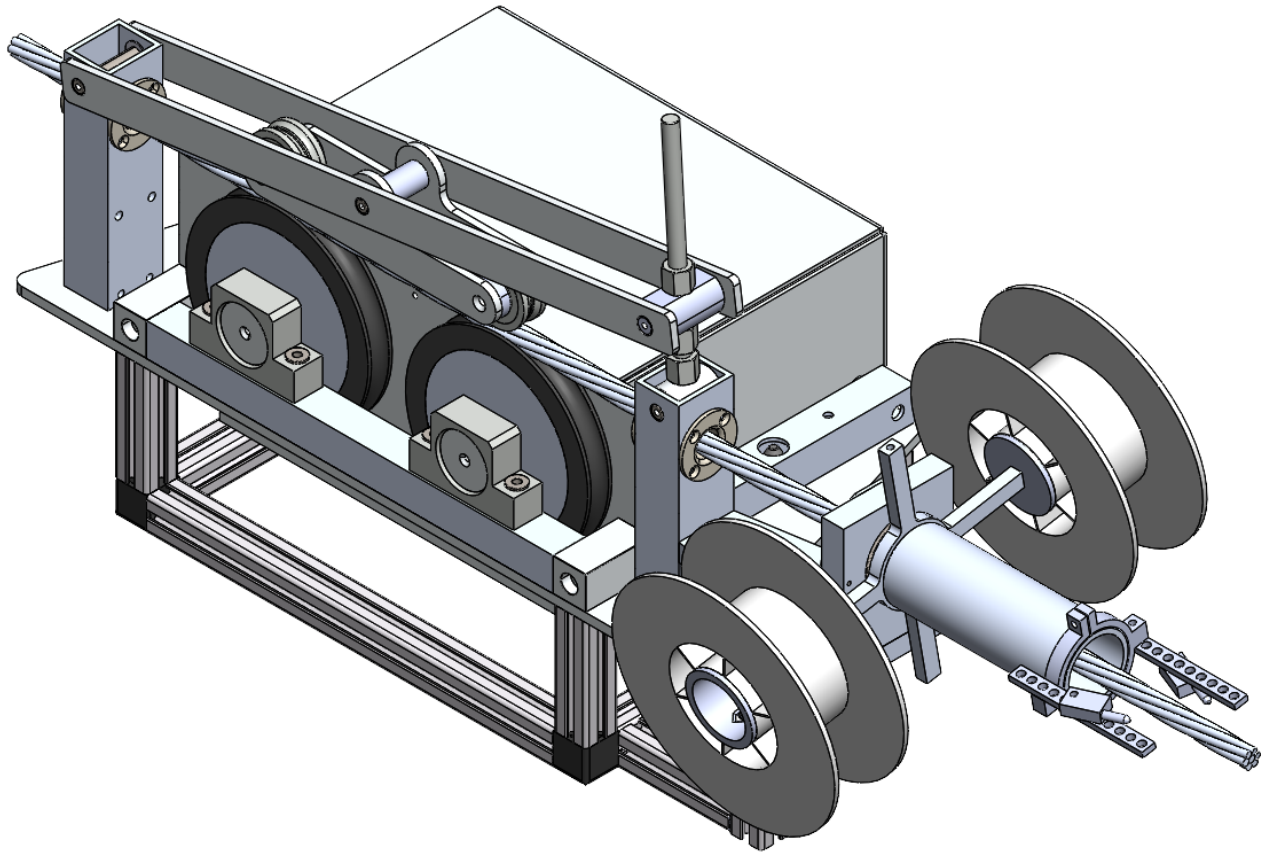
Smart Tendon Installation & Measurements

Fiber integration into the strands



- Fiber insertion into strand

Smart Tendon Installation & Measurements

Impressions Thailand Laos- Jan 2025

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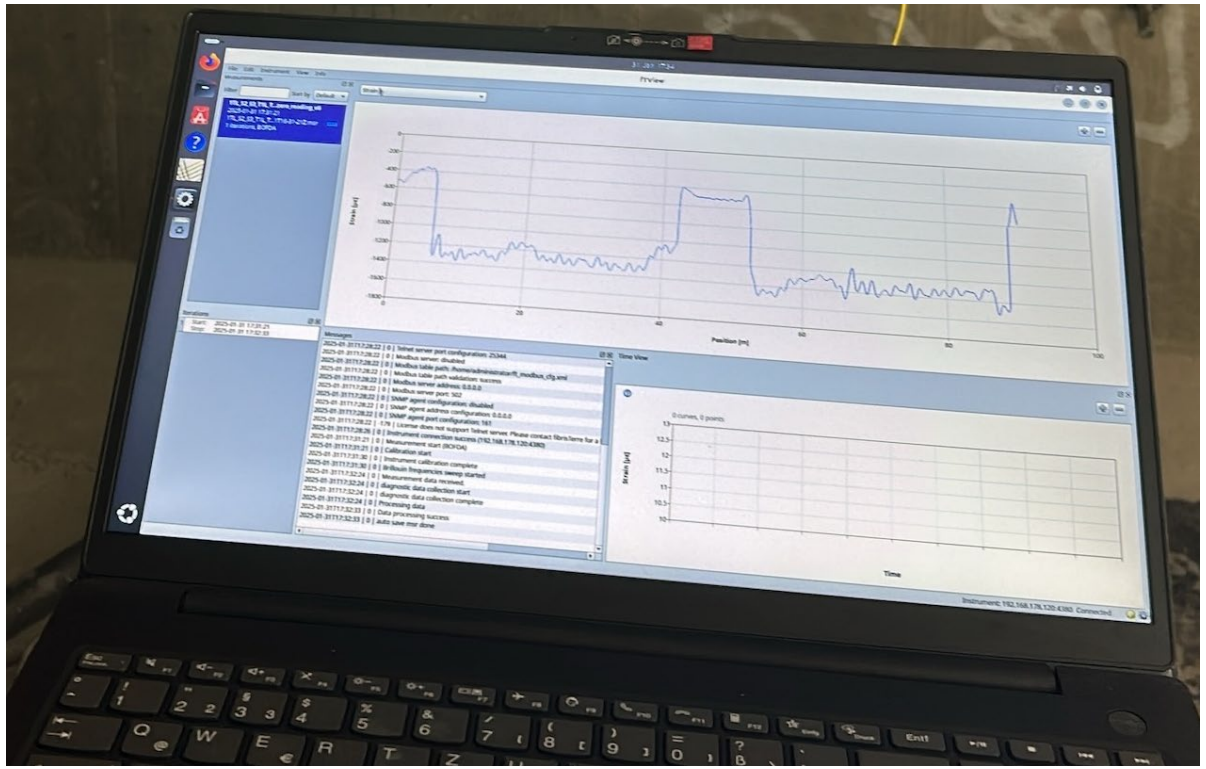
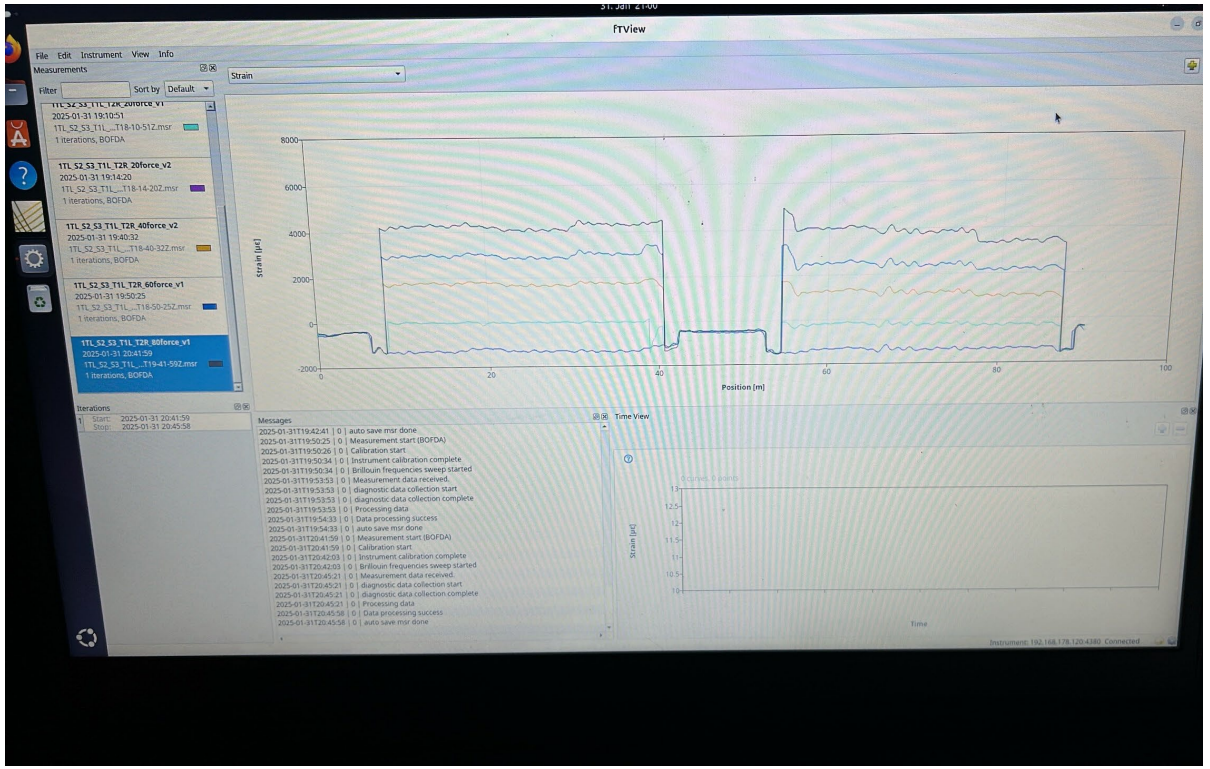
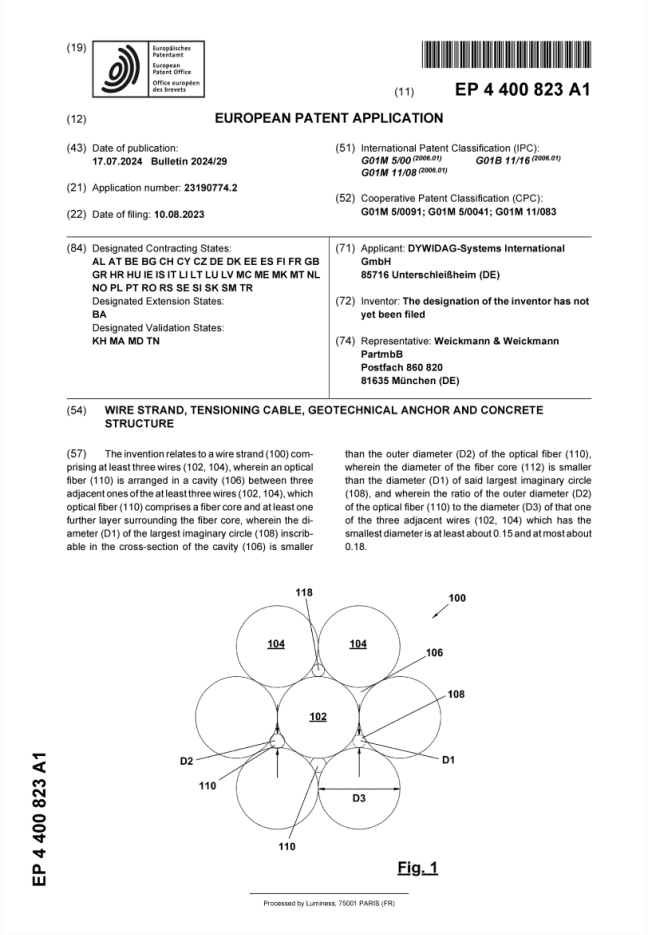


Pre-Tension-Reading



Post-Tension-Reading

DYWIDAG PEP (EU) and PCT (International) Patent & Publications



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(72) Inventor: **The designation of the inventor has not yet been filed**

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(54) **WIRE STRAND, TENSIONING CABLE, GEOTECHNICAL ANCHOR AND CONCRETE STRUCTURE**

(57) The invention relates to a wire strand (100) comprising at least three wires (102, 104), wherein an optical fiber (110) is arranged in a cavity (106) between three adjacent ones of the at least three wires (102, 104), which optical fiber (110) comprises a fiber core and at least one further layer surrounding the fiber core, wherein the diameter (D1) of the largest imaginary circle (108) inscribable in the cross-section of the cavity (106) is smaller than the outer diameter (D2) of the optical fiber (110), wherein the diameter of the fiber core (112) is smaller than the diameter (D1) of said largest imaginary circle (108), and wherein the ratio of the outer diameter (D2) of the optical fiber (110) to the diameter (D3) of that one of the three adjacent wires (102, 104) which has the smallest diameter is at least about 0.15 and at most about 0.18.

Fig. 1

EP 4 400 823 A1

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TestSMAR 2024 – 7th International Conference on Smart Monitoring, Assessment and Rehabilitation of Civil Structures

Distributed fiber optic sensing for early-age monitoring of concrete structures

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Abstract

Abstract hier

Test

Peer-review under responsibility of SMAR 2024 Organizers
Keywords: structural health monitoring; fiber optic sensing; distributed strain sensing; early age monitoring; large-scale experiments

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Peer-review under responsibility of SMAR 2024 Organizers

Förderverein Massivbau der TU München e.V.

27. Münchener Massivbau Seminar

24. November 2023

Zustandsbewertung von Spannbetonbauwerken anhand von in Spannglieder integrierter ortsauflösender Sensoren (smart tendons)

https://doi.org/10.14459/2023.1724792.mbs27.07

Christian Gläser

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1995-2000 Studium Bauingenieurwesen, TU München
2000-2007 Wissenschaftlicher Mitarbeiter und Promotion am Lehrstuhl für Massivbau der TU München
2007-2009 Technischer Betriebsleiter des MPA BAU der TU München
2009-2018: CEO Europe für den Bereich Vorspanntechnik bei DYWIDAG
2018-2020: President Mega Projects bei DYWIDAG
Seit 2020: Chief Technology Officer bei DYWIDAG, seit 2022 President Corporate Development

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Technische Universität München

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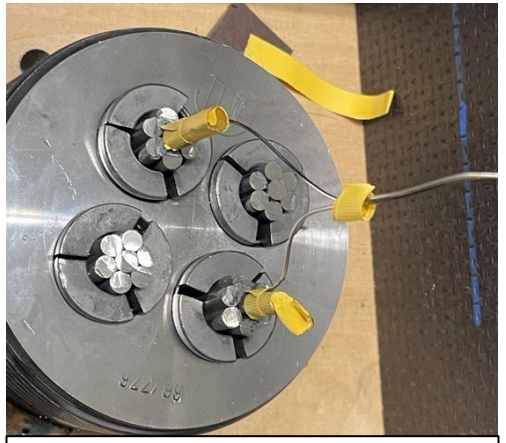
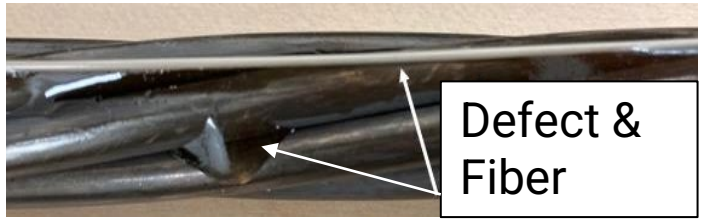
Smart Tendon

- Grouting errors **>100 mm** and cracks in the grouting can be detected
- Creep can be measured
- Fiber integration into the strand will be done with a portable automated machine (either in the factory or on site)
- Wedge gripping (transversal pressure) is not damaging the fiber
- Readout with a portable unit can be done on demand

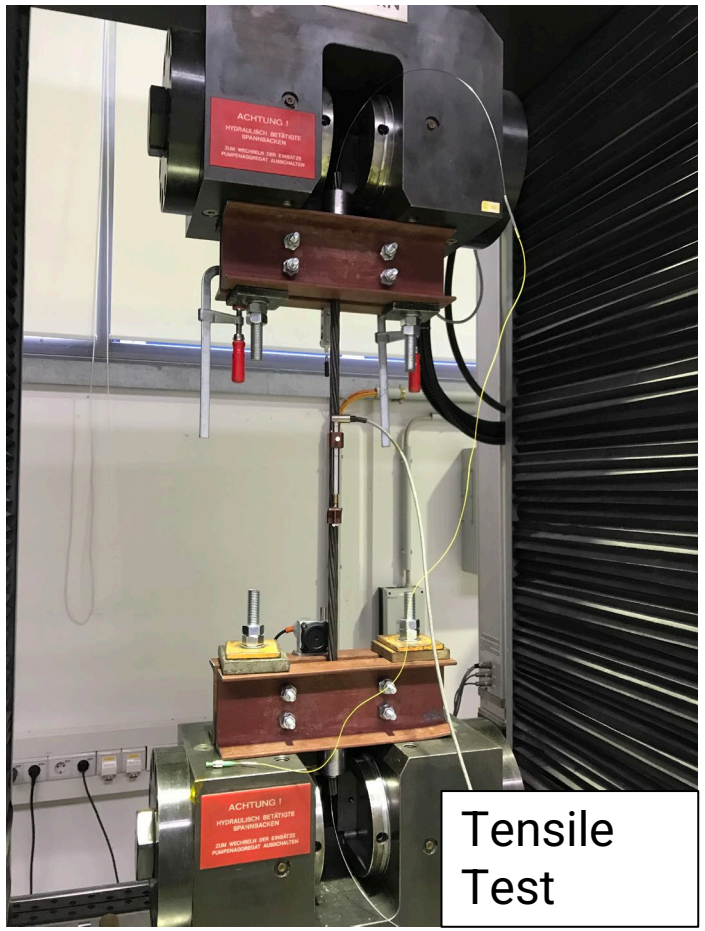


Fiber after insallation in anchorage



Defect & Fiber

Fiber with corrosion protection system applied



Tensile Test

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