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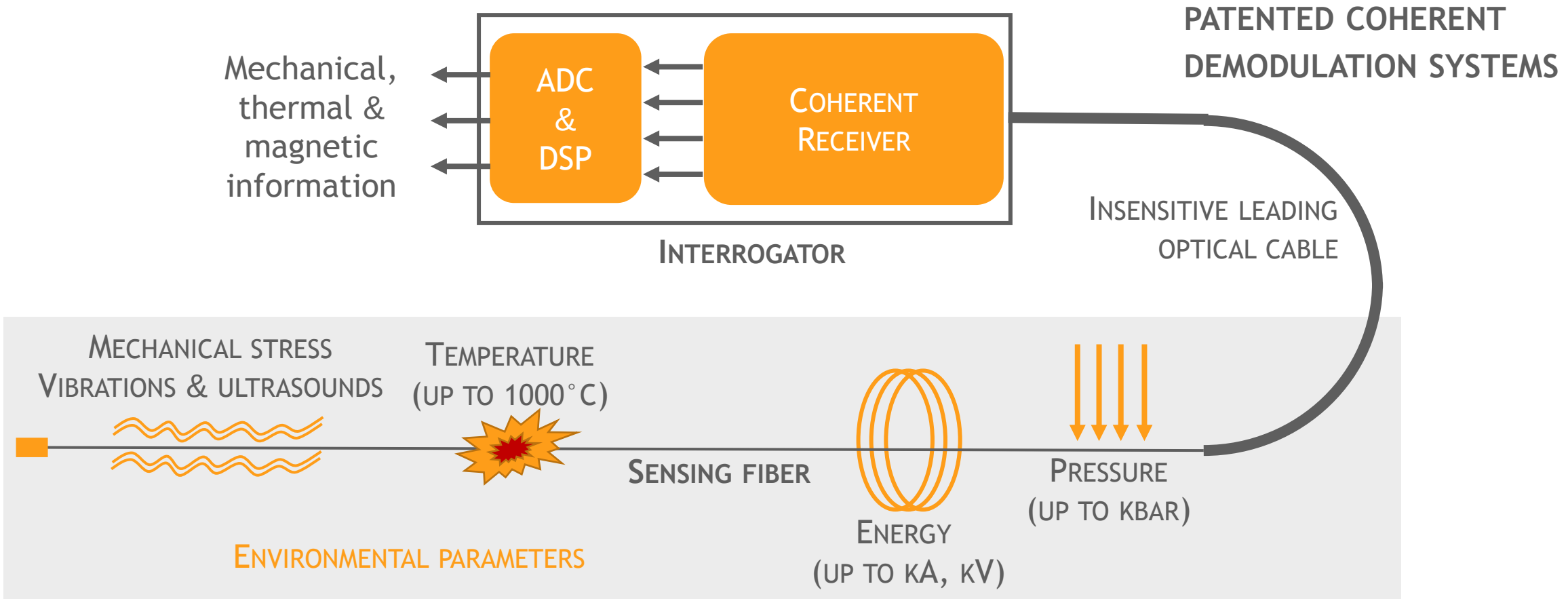
FIBER OPTIC SENSORS FOR THE PROTECTION AND CONSERVATION OF CULTURAL HERITAGE

ONE SENSING TECHNOLOGY for a **MULTIPURPOSE MONITORING**



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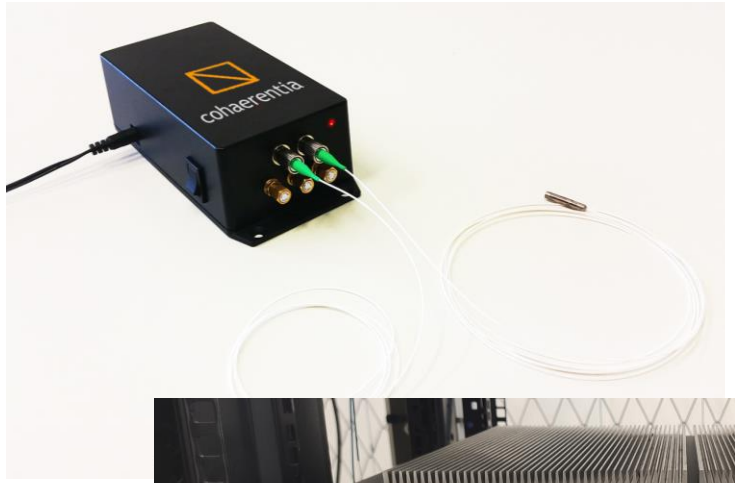
COHAERENTIA TECHNOLOGY: **KEY FEATURES**

ONE SENSING FIBRE → EQUIVALENT TO THOUSANDS OF STRAIN-GAUGES OR THERMOCOUPLES.

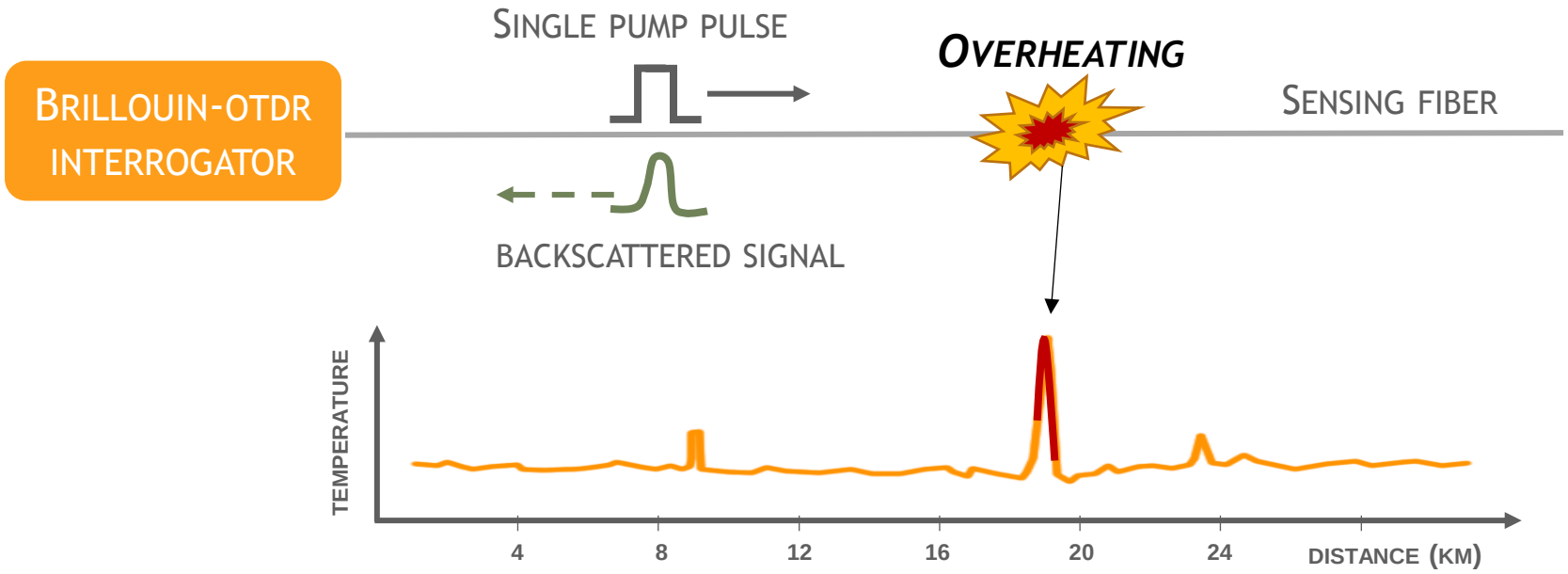
→ **NO NEED OF A PLURALITY OF CONVENTIONAL SENSORS** ARRANGED IN COMPLEX AND COSTLY ARCHITECTURES.



- VERSATILE AND COST-EFFECTIVE
- REMOTE DIAGNOSTIC OF **HARSH ENVIRONMENTS** OR INACCESSIBLE SPOTS
- **IMMUNITY TO EM** INTERFERENCE
- NO POWERING & MAINTENANCE ISSUES AS IN WIFI NETWORK SENSORS

FIBER OPTIC DISTRIBUTED MEASUREMENT PRINCIPLE

- OTDR APPROACH (**RAMAN / BRILLOUIN TECHNOLOGY**)



- **A PUMP PULSE** IS SENT INTO THE FIBER AND THE **BACKSCATTERING SIGNAL** GENERATED IN EACH SINGLE POINT OF THE FIBER IS ANALYZED.
- **TEMPERATURE** WITH **METER** SPATIAL RESOLUTION, ARE RECOVERED OVER TENS OF KM.

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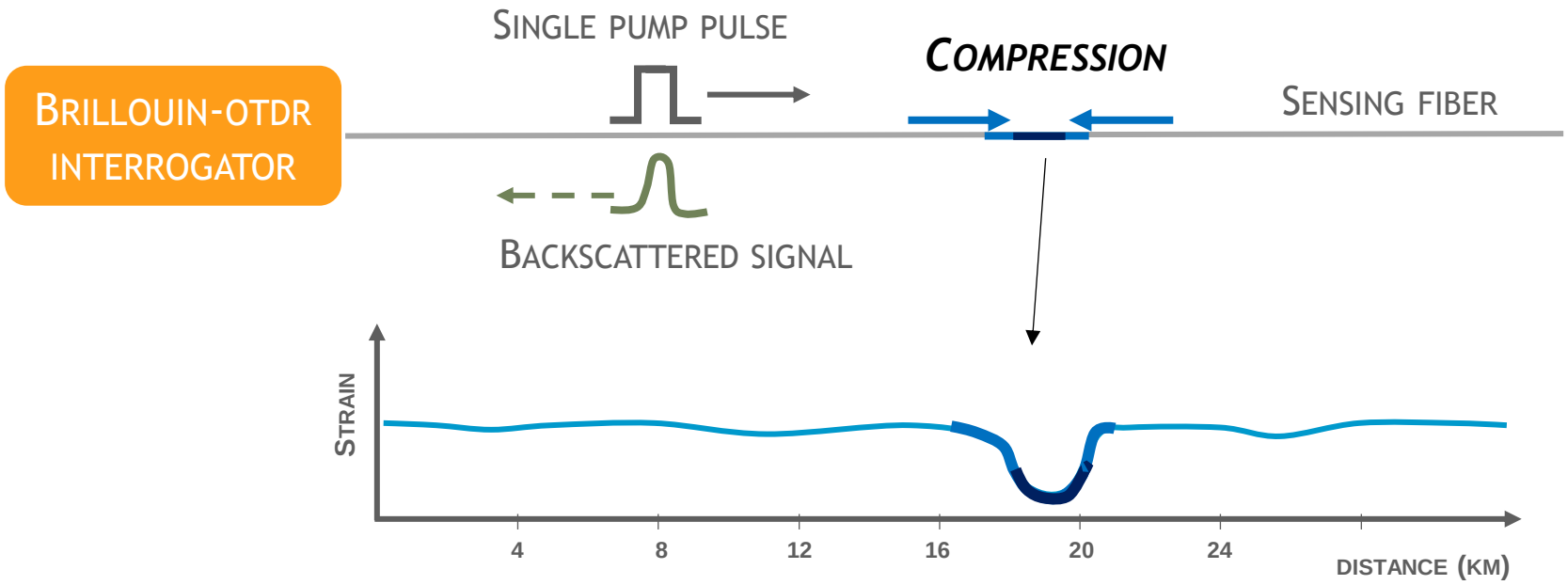
FIBER OPTIC DISTRIBUTED MEASUREMENT PRINCIPLE

- OTDR APPROACH (BRILLOUIN /DAS TECHNOLOGY)



- A PUMP PULSE IS SENT INTO THE FIBER AND THE BACKSCATTERING SIGNAL GENERATED IN EACH SINGLE POINT OF THE FIBER IS ANALYZED.
- **STRAIN OR VIBRATION PROFILES** WITH **1 METER SPATIAL RESOLUTION** OVER TENS OF KM CAN BE RECOVERED.

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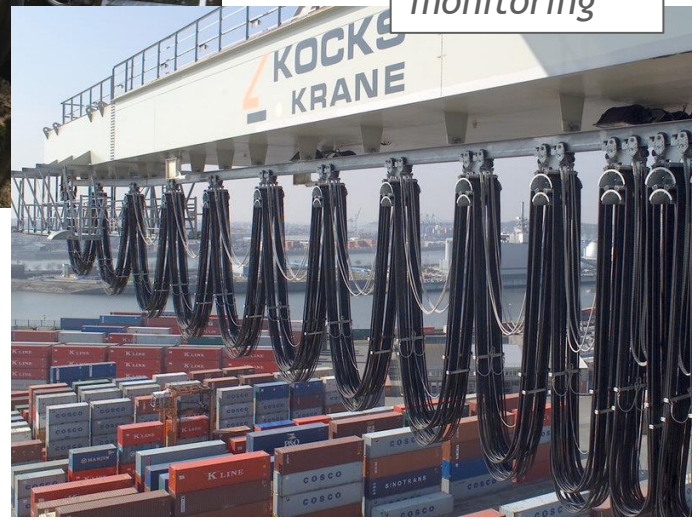
STRUCTURAL HEALTH MONITORING

- MONITORING OF WATER PIPE MOVEMENTS ON LANDSLIDE SLOPES.
- MONITORING OF DYNAMIC AND STATIC DEFORMATIONS OF BRIDGES, VIADUCTS AND ENERGY CABLES.
- LEVEE MONITORING WITH DISTRIBUTED TEMPERATURE AND DEFORMATION MEASUREMENTS.

Bridge structural health diagnostic

Subsidence and infiltration monitoring along levees

Displacement sensors along a water pipe on a landslide



Energy cable monitoring

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BRIDGE MONITORING

STRUCTURAL HEALTH MONITORING OF A HISTORICAL WATER PENSTOCK BRIDGE POSITIONED OVER THE DORA DI RHÊMES CANYON (INTROD) IN VALLE D'AOSTA REGION, REPRESENTING ONE OF THE FIRST EXAMPLES OF A CONCRETE BRIDGE BUILT IN THE 1920S.

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BRIDGE MONITORING

SENSING FIBER INSTALLATION ON THE BRIDGE TO MONITOR DEFORMATION INDUCED BY THE **GEOLOGICAL MOVEMENTS** OF THE SURROUNDING MOUNTAINS.

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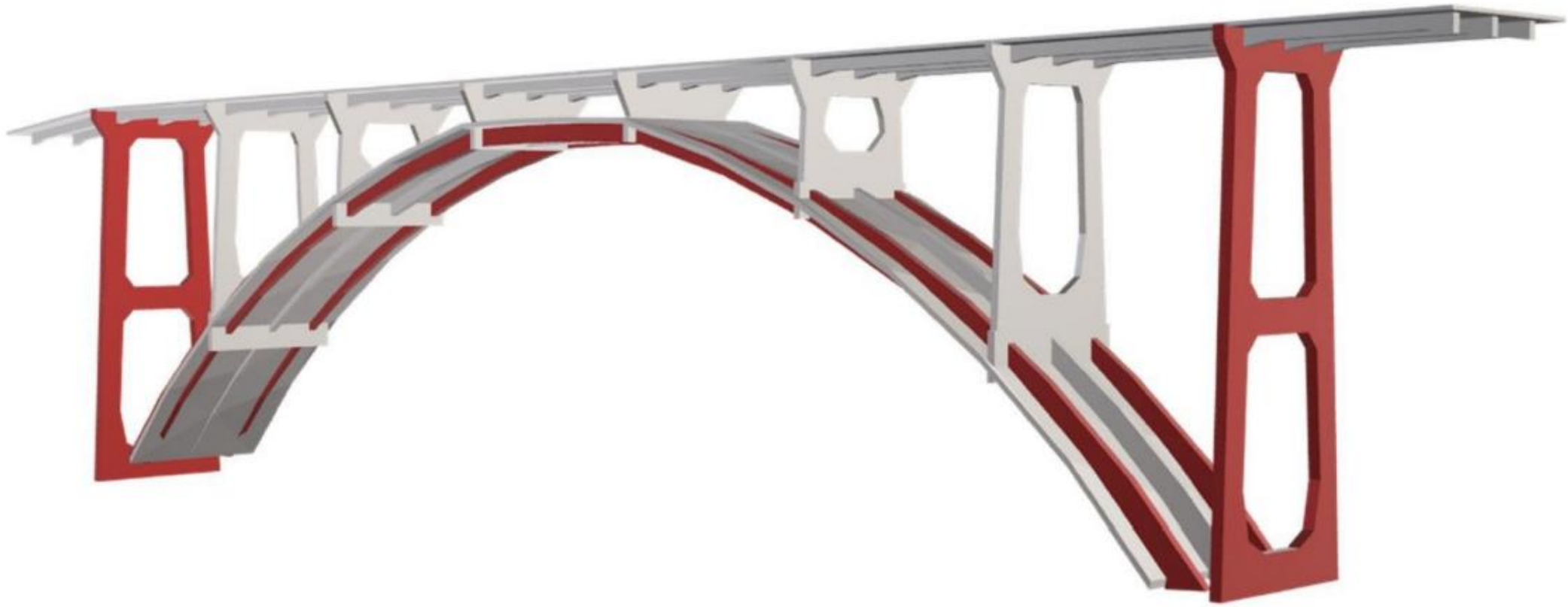
BRIDGE MONITORING

SCHEME OF THE BRIDGE WITH THE MONITORED MEMBERS HIGHLIGHTED IN RED.

OPTICAL SENSING FIBERS ALLOW TO **RECONSTRUCT THE ENTIRE DEFORMATION PROFILE** OF THE BRIDGE WITH A METER SPATIAL RESOLUTION.



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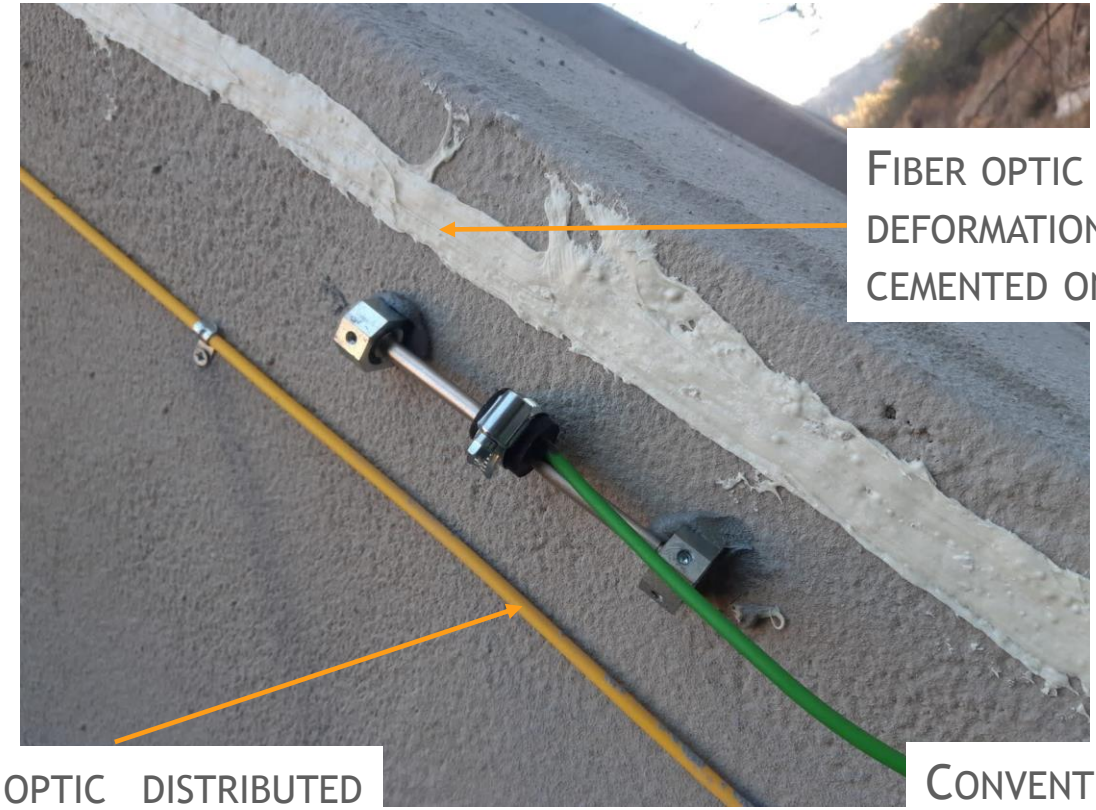
BRIDGE MONITORING

Bridge monitoring performed with both conventional strain gauges and accelerometers and fiber optic distributed sensors.



Fiber optic distributed deformation sensor cemented on the structure

Fiber optic distributed temperature sensor

Conventional strain gauge

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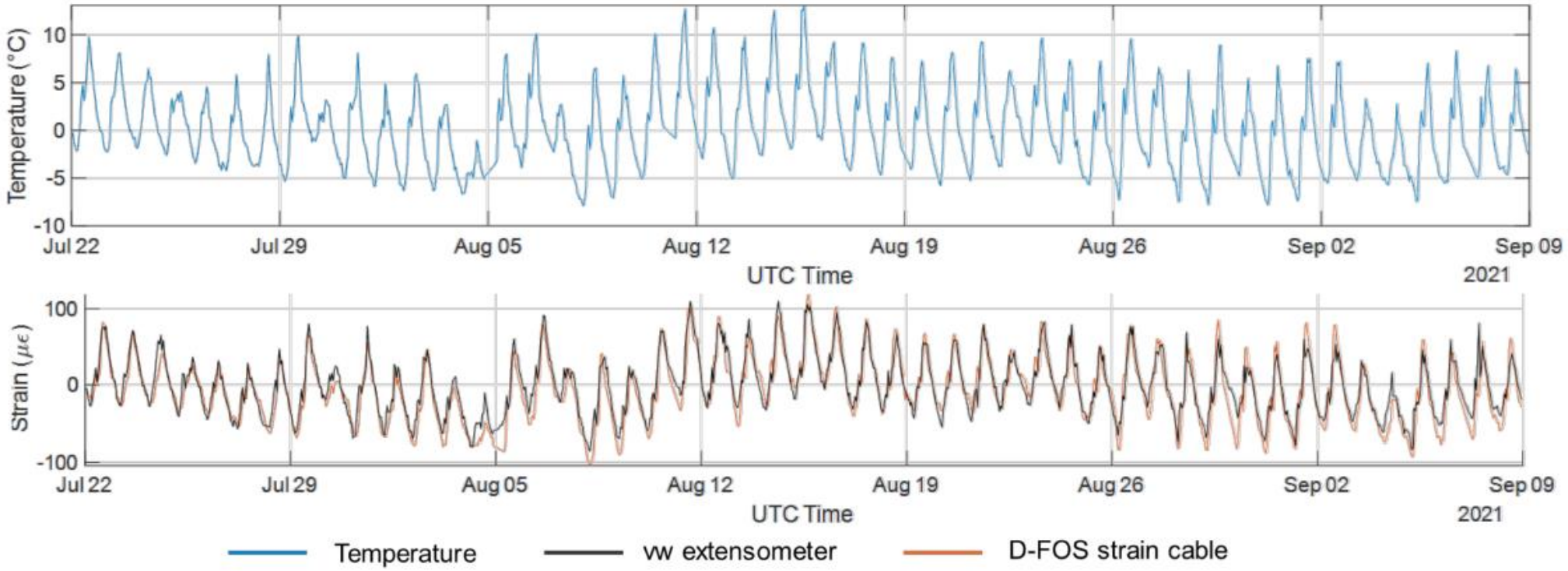
TEMPERATURE AND STRAIN MEASURES

COMPARISON OF THE STRAIN PROFILE OBTAINED RESPECTIVELY BY THE VW EXTENSOMETER AND THE FIBER STRAIN CABLE AT POSITION A1 (FORM 22 JULY 2021 TO 9 SEPTEMBER 2021).



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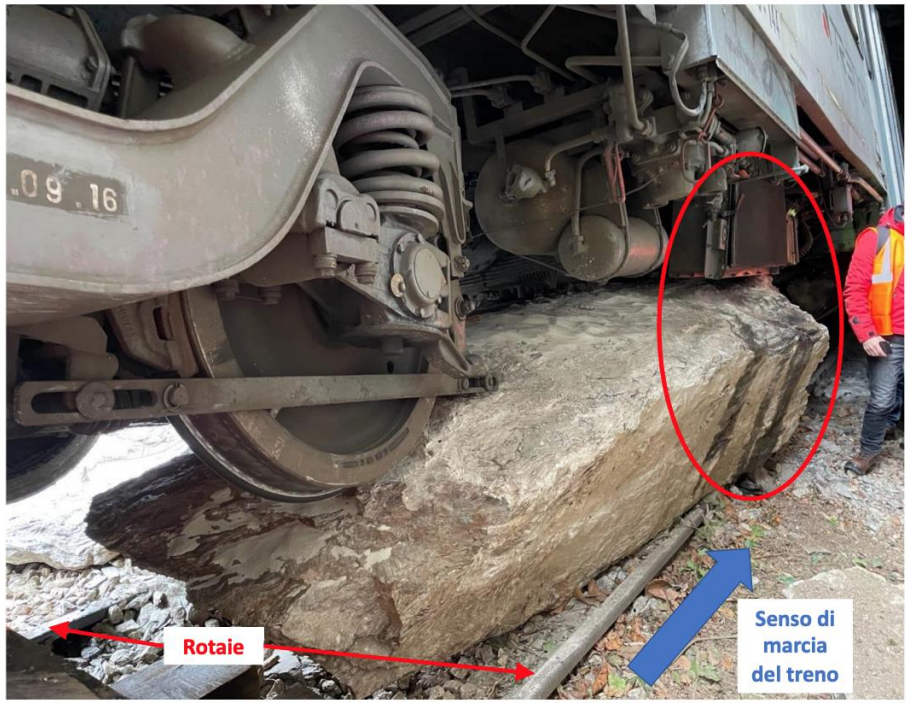
RAILWAY MONITORING

DECEMBER 2021: ROCKFALL AT THE ENTRANCE TO A NATURAL TUNNEL ON THE BRESCIA-EDOLO RAILWAY TRACK DUE TO INSTABILITY OF THE MOUNTAIN SIDE.



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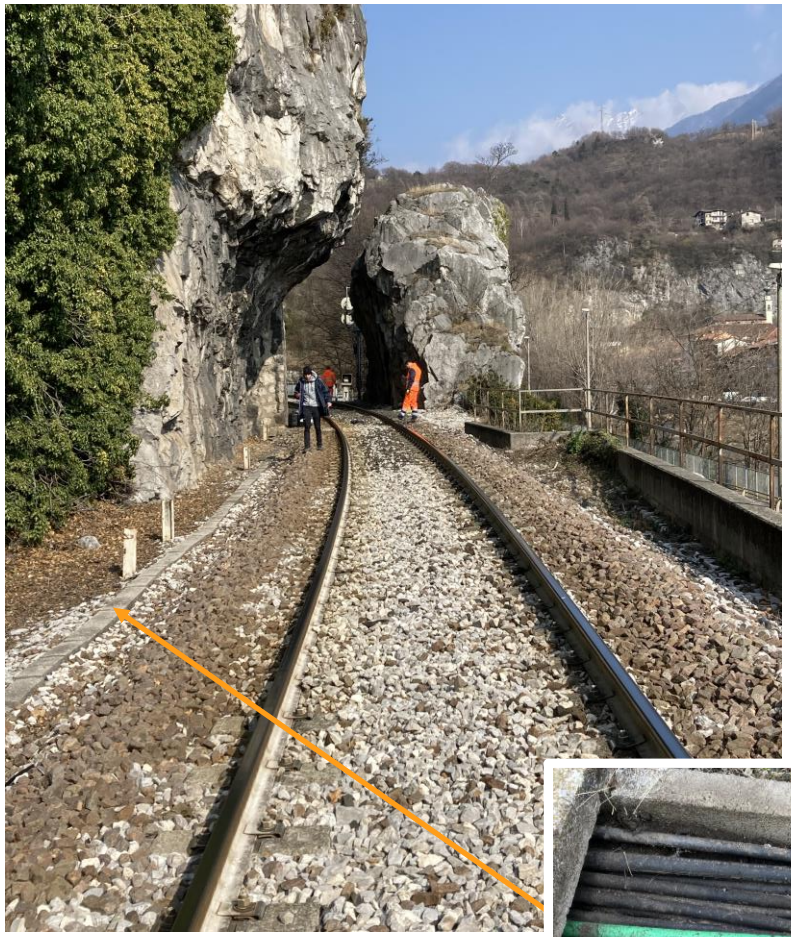
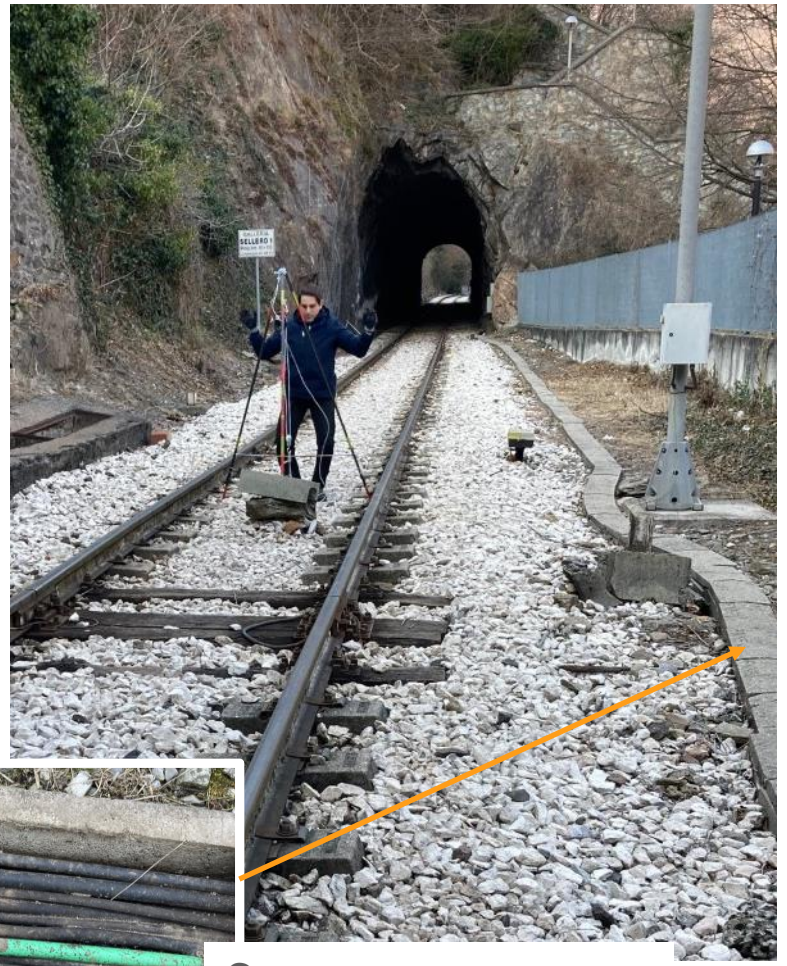
RAILWAY: ROCKFALL MONITORING

OPTICAL FIBERS ALREADY INSTALLED ALONG THE RAILWAY TRACK ARE USED AS SENSORS TO DETECT ROCKFALL EVENTS.





OPTICAL FIBER CABLES INSIDE THE DUCT.

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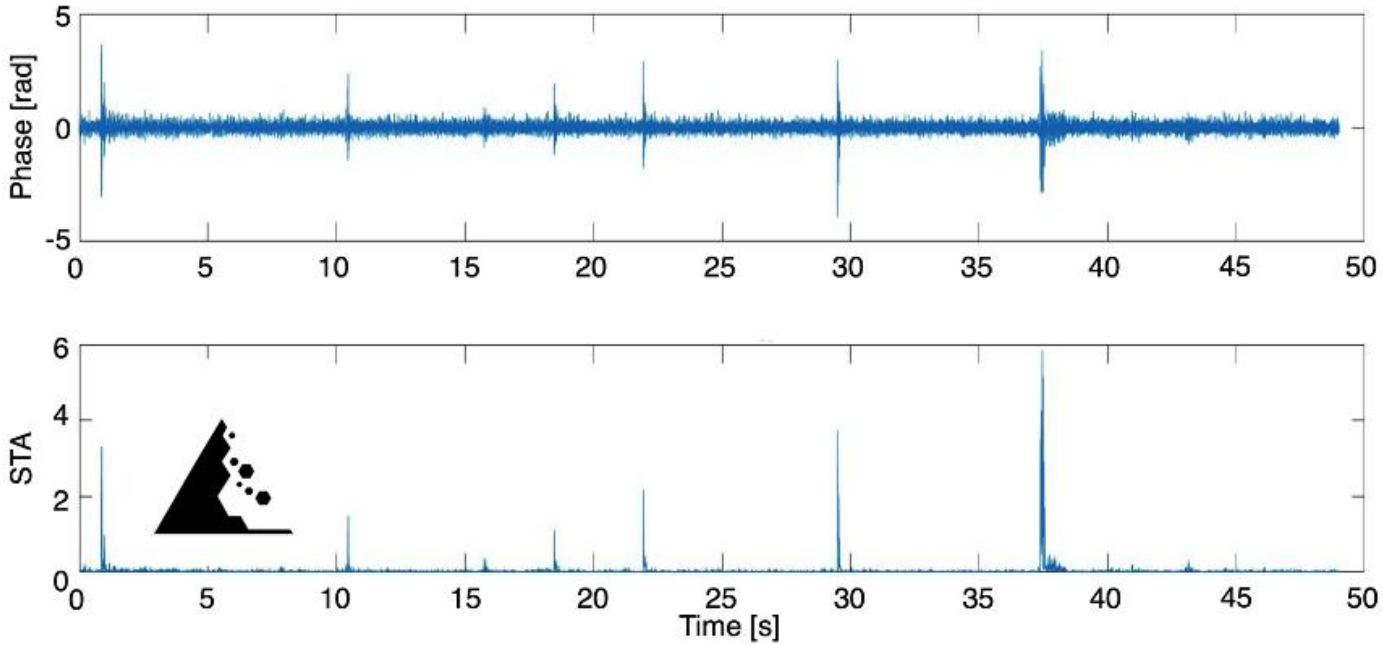
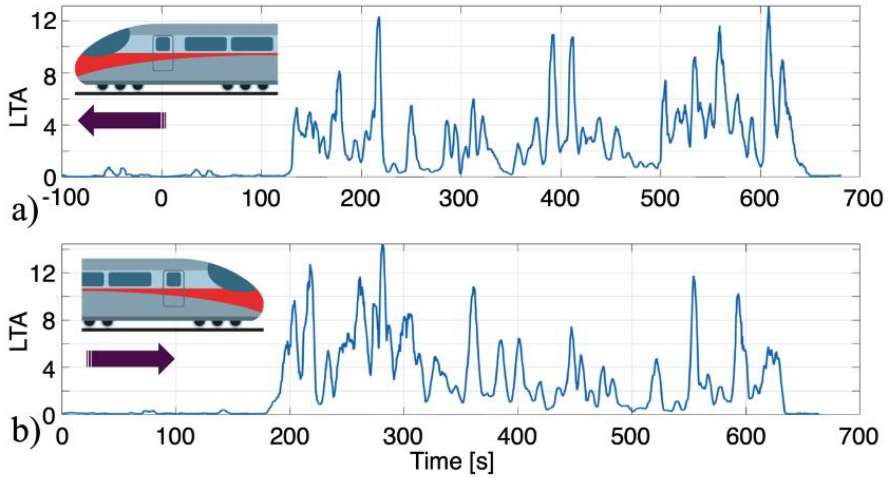
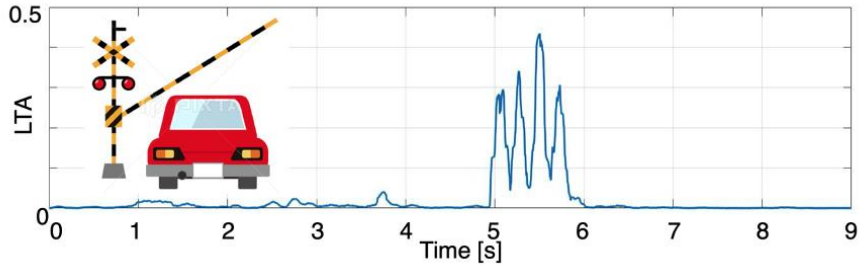
RAILWAY MONITORING

THE OPTICAL SYSTEM INSTALLED ALONG THE RAILWAY DETECTS FALLING ROCK PHENOMENA, THE PASSAGE OF TRAINS AND CARS PASSAGES AT LEVEL CROSSINGS.







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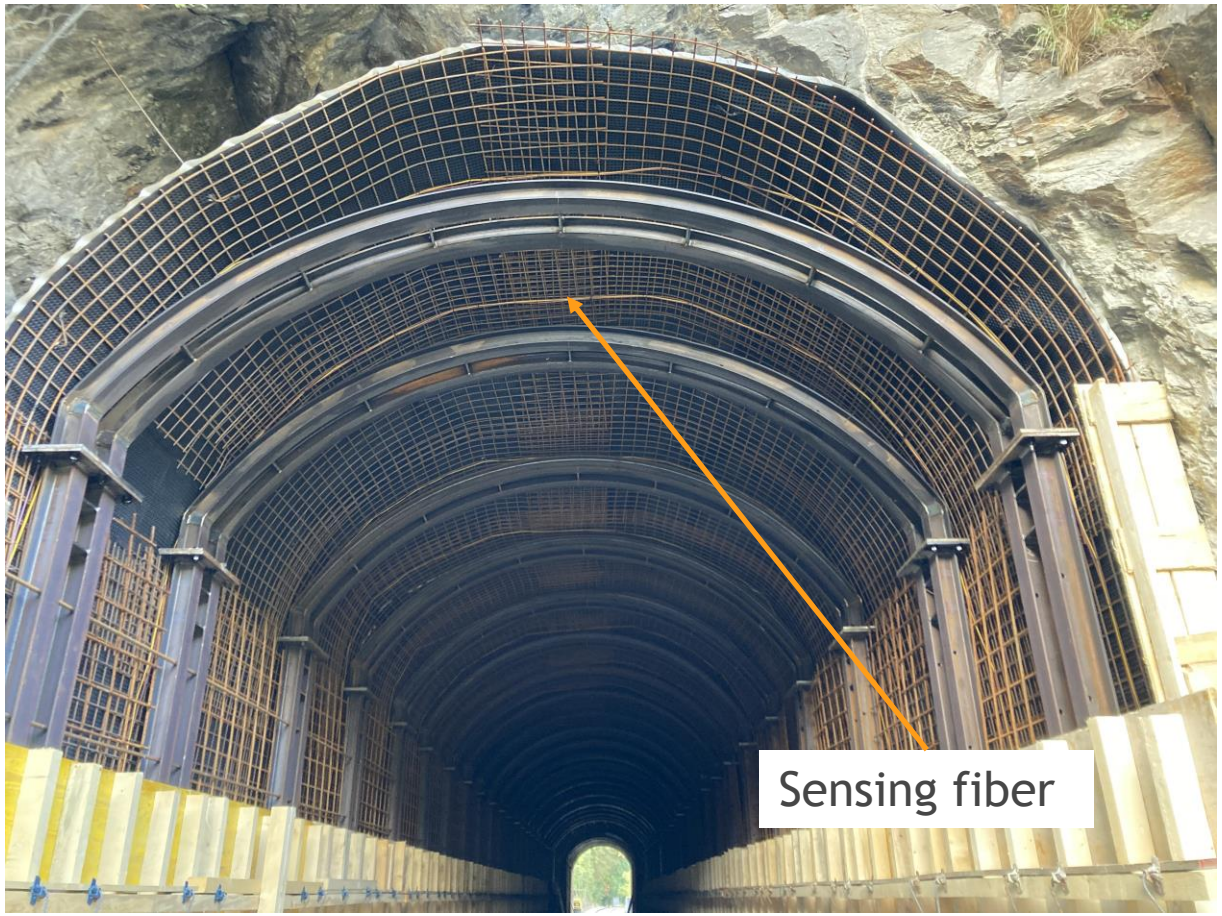
RAILWAY: TUNNEL MONITORING

MONITORING OF DEFORMATIONS CAUSED BY GEOLOGICAL MOVEMENTS ON RAILWAY TUNNELS, THROUGH SENSING FIBERS INSTALLED ON METAL RIBS.



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FIBER OPTIC SENSORS:
A NEW TECHNOLOGY
FOR CULTURAL HERITAGE
SURVILLIANCE

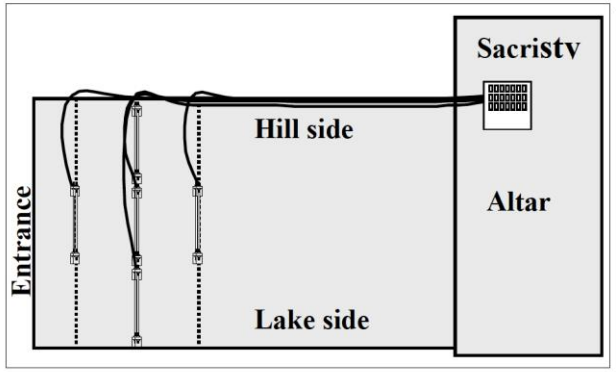
STRUCTURAL HEALTH MONITORING OF HISTORICAL MONUMENTS

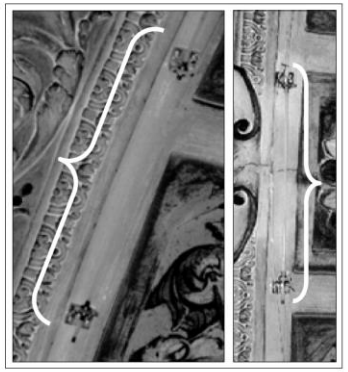
CLASSIC TECHNIQUES FOR CULTURAL HERITAGE CONSERVATION REQUIRE OPERATORS ON SITE ASSIGNED TO CONTROL, BUT USUALLY IT IS ONLY TO PROVE A DAMAGE THAT HAS ALREADY OCCURRED.

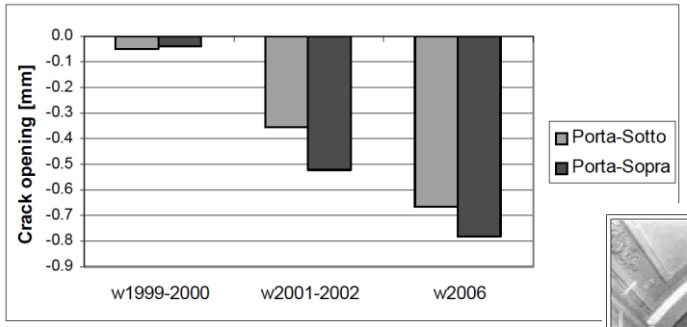
FIBER OPTIC SENSORS CAN INSTEAD GUARANTEE A REAL-TIME CONSTANT MONITORING AND PROTECTION AGAINST THE LONG-TERM EFFECTS OF POSSIBLE RISK FACTORS.

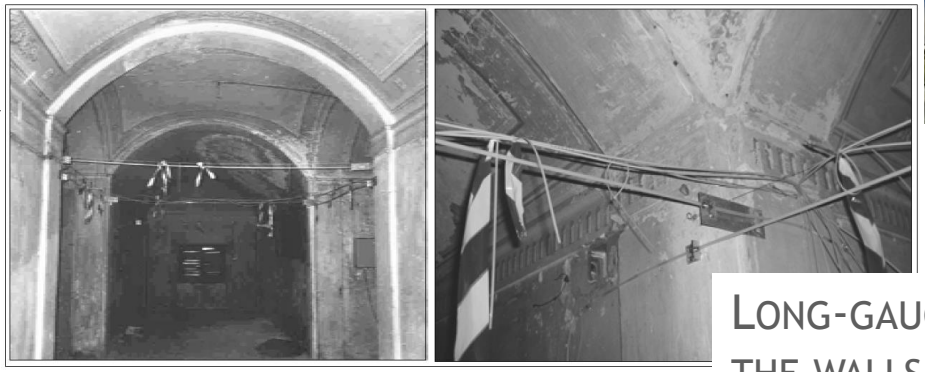
VILLA REALE IN MONZA

IN THE EARLY 2000S, FIBER OPTICS WERE INSTALLED AS STRAIN GAUGES TO MONITOR THE PROGRESS OF CRACKS AND THE RELATIVE DISPLACEMENT OF OPPOSITE WALLS.









LONG-GAUGE SENSORS INSTALLED BETWEEN THE WALLS IN MAIN CORRIDORS.

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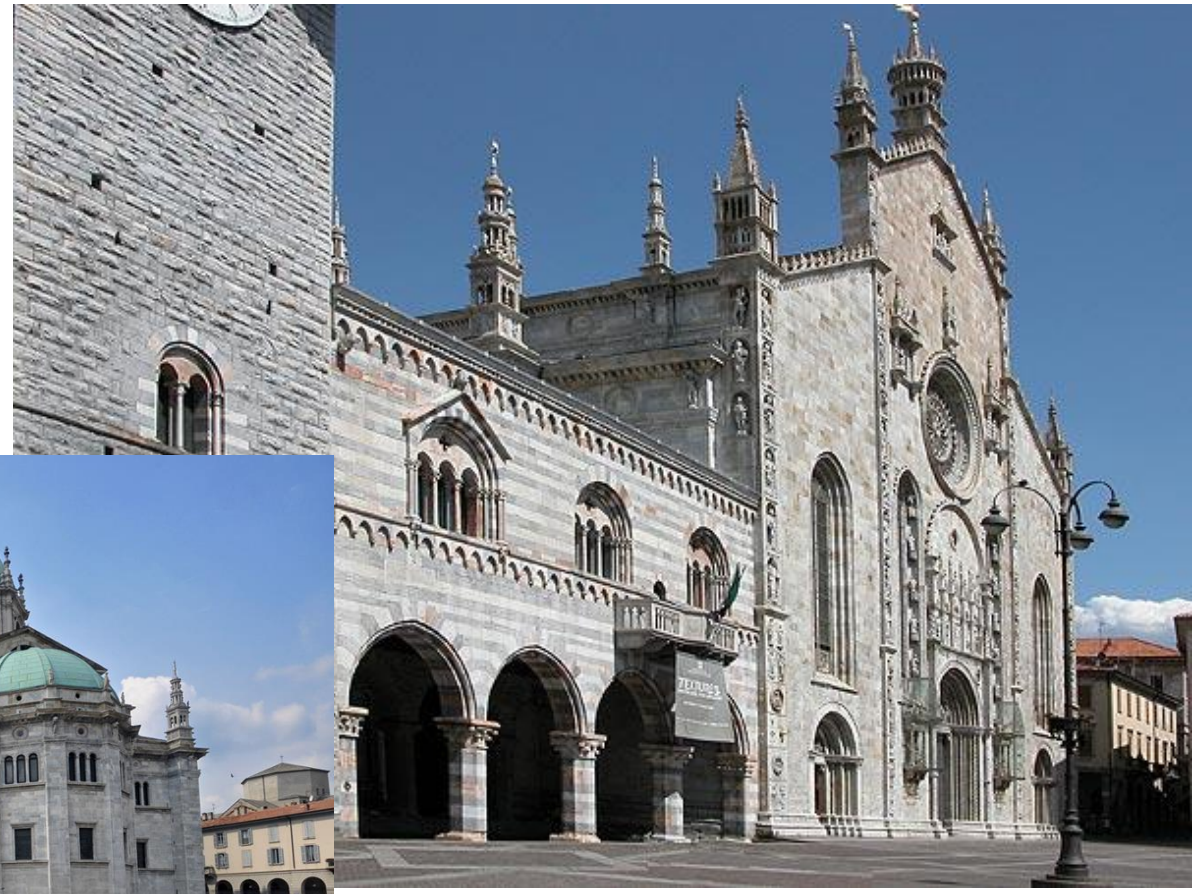
CATHEDRAL OF COMO

In 2001, fiber optic lines were installed above and below the primary arch of the Cathedral of Como to identify any structural deteriorations, to protect this important cultural heritage built in 1396.

Fiber sensors allowed to monitor:

- opening of cracks;
- displacements between the 4 columns that support the dome;
- Deformations and temperatures in selected points



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EU PROJECT **POLYTECT**

SMART TEXTILES WITH EMBEDDED FIBER OPTIC SENSORS IS A COST-EFFECTIVE SOLUTION TO REINFORCE AND, AT THE SAME TIME, **MONITOR MASONRY AND HERITAGE STRUCTURES**, SUPPORTING THE ASSESSMENT OF THE STATE OF THE STRUCTURE AFTER AN **EARTHQUAKE.**

THESE SMART TEXTILE HAS BEEN DEPLOYED TO STRENGTHEN AND MONITOR SOME VAULTS AND MASONRY BUTTRESSES OF THE **MONASTERY OF SANT'ANGELO D'OCRE, L'AQUILA.**

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Thank you!

www.cohaerentia.com
info@cohaerentia.com

via Ponzio 34/5
20133 Milan
Italy

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