



Dynamic and Static Monitoring Solutions for Civil Engineering Structures

WHY DO WE MONITOR STRUCTURAL HEALTH?

Structural Health Monitoring (SHM) is essential for a wide range of structures, including bridges, wind farms, pipelines, tunnels, oil rigs, ships, planes, and trains as well as other related infrastructures. These structures are constantly exposed to internal and external factors that can lead to wear, malfunction, or damage. Factors such as deterioration, construction errors, lack of quality control, accidents, or environmental loads can contribute to structural issues.

Implementing a robust monitoring system is crucial to observe material changes and detect anomalies in structural behaviour ensuring the safety of users and of the infrastructure. By identifying issues in a timely manner, maintenance and repair actions can be implemented more efficiently, resulting in reduced operating costs. The primary objective of infrastructure monitoring is to shift from schedule-driven maintenance to condition-based maintenance:

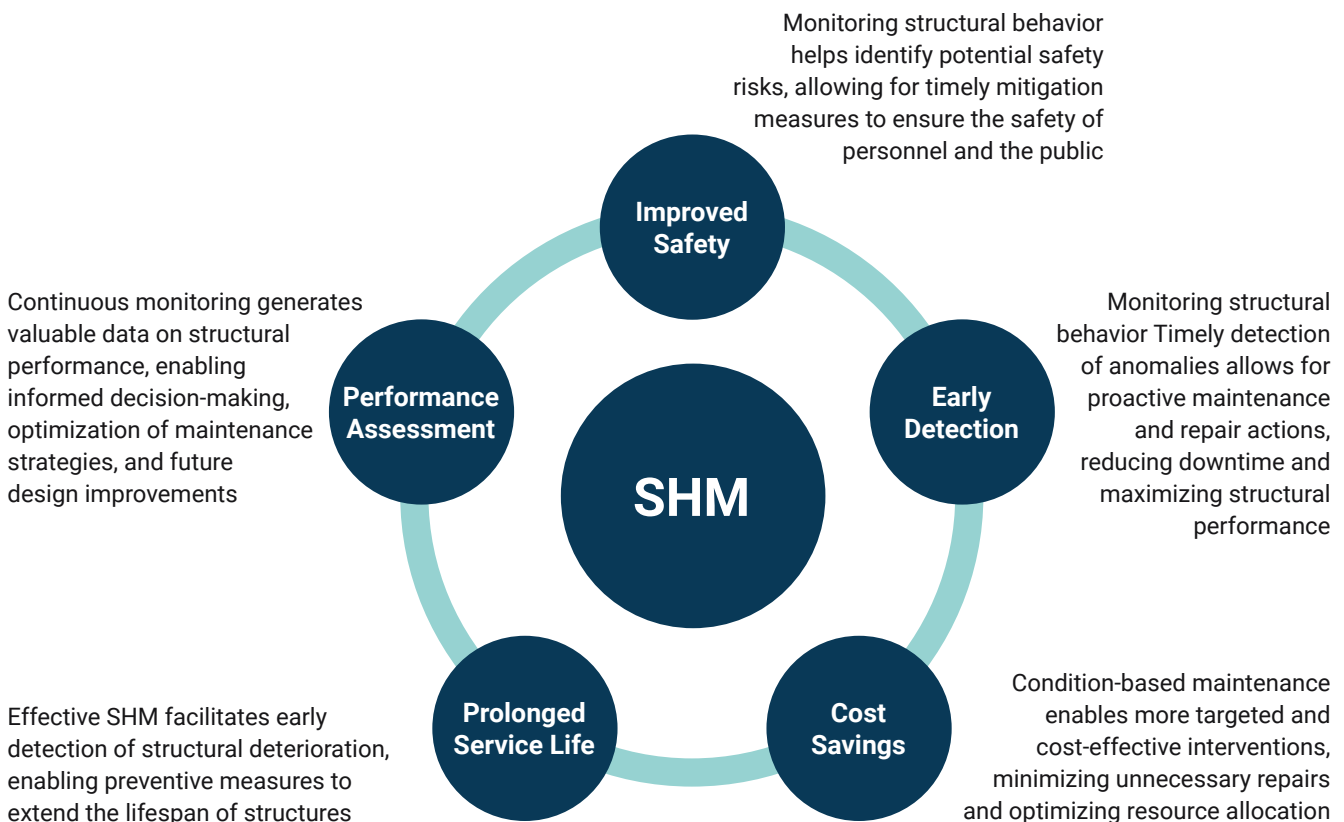
- **Improved Safety**
- **Early Detection**
- **Cost Savings**
- **Prolonged Service Life**
- **Performance Assessment**

WHO IS HBK?

Hottinger Brüel & Kjær (HBK) provides integrated solutions and domain expertise across the test and measurement product life cycle, bridging the gap between the physical world of sensors, testing and measurement and the digital world of simulation, modelling software and analysis.

HBK provides a comprehensive portfolio of solutions for structural health monitoring including a wide range of components from sensors to software, including different technologies for a best fit to the needs. Electrical or optical sensors such as strain gauges, accelerometers, displacement sensors, load sensors, among others, including the most suited acquisition systems, software, data transmission and powerful analysis tools.

Our modular test and measuring equipment combined with our highly skilled team at HBK offer exceptional support and service with all aspects of your project. Whether you require guidance, troubleshooting, or project management, we are here to help.



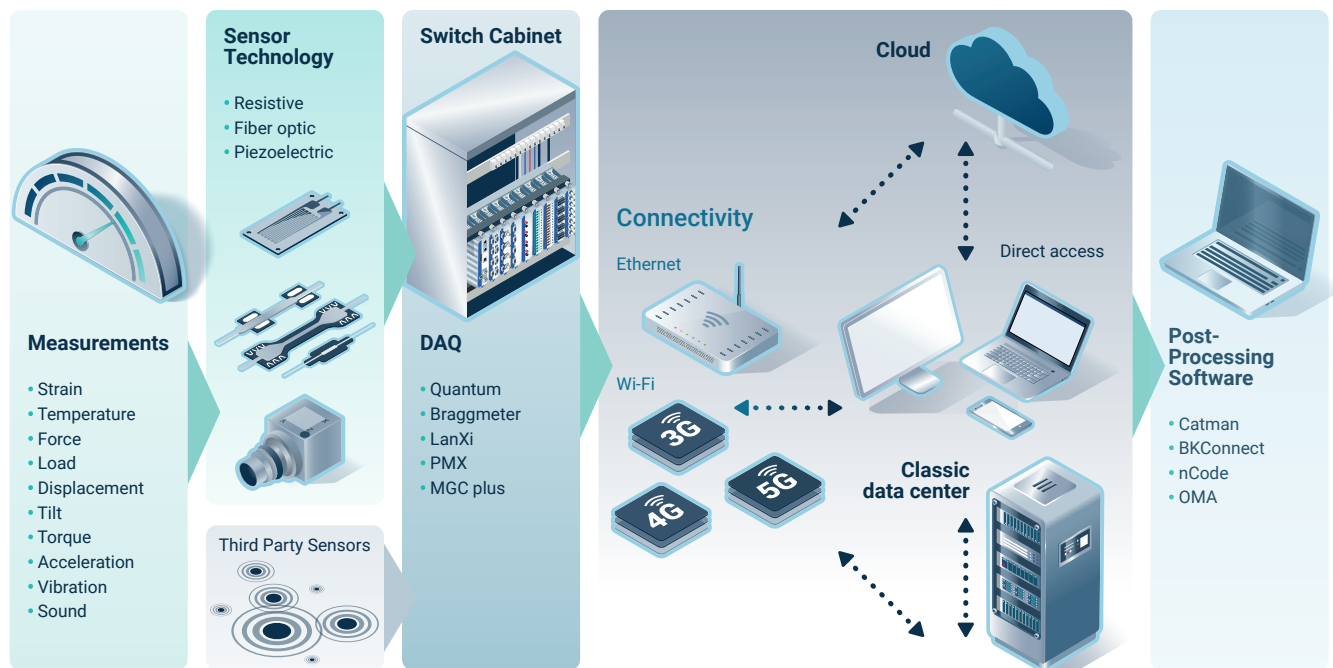
WHY CHOOSE HBK FOR STRUCTURAL HEALTH MONITORING?

- Modular SHM portfolio:** HBK offers a modular SHM portfolio, allowing you to tailor your solution according to your specific needs. Whether you require individual sensors, a complete measuring system, or a turnkey solution for your structure, HBK provides the flexibility to choose the components that suit your requirements
- Expertise in multiple sensor technologies:** HBK excels in both strain gauge-based and optical sensors. Instead of promoting a specific technology, HBK focuses on understanding your needs and recommending the most suitable solution. If a combination of technologies offers an advantage, HBK seamlessly integrates them to achieve optimal results
- Field proven technology and in-house R&D:** With field-proven technology and a robust research and development (R&D) division, HBK ensures that its SHM solutions are reliable, accurate, and meet the highest industry standards. This commitment to technological excellence is backed by HBK's own manufacturing facilities, ensuring quality control throughout the production process

- Experienced engineering services team:** HBK boasts a highly experienced engineering services team with extensive knowledge and expertise in SHM. Their proficiency enables them to provide comprehensive support and guidance throughout the implementation and operation of your SHM system
- Strong references:** HBK's track record of successful SHM projects serves as a testament to our expertise and capability
- Global presence:** Our global presence allows us to serve clients across different regions. This global reach ensures that our SHM solutions are accessible and available to customers worldwide

THE MODULAR HBK SOLUTION

HBK's modular and scalable monitoring solutions, complemented by our competent support and service, save time and money, provide valuable insights, and help to increase the structure's service life and safety.



HBK Engineering Services

STRAIN GAUGES FOR EXPERIMENTAL STRESS ANALYSIS OFFER BOTH HIGH PERFORMANCE AND COST-EFFECTIVENESS

From fatigue testing of an aircraft wing, strain analysis of a printed circuit board, to structural monitoring of a bridge or residual stress measurement, HBM strain gauges for experimental stress analysis are used to determine the level of stress on a material. Benefit from over 65 years of experience, a broad range of standard products that are available from stock, a committed customer service, and an excellent knowledge transfer. Alongside four standard series of high-quality strain gauges for stress analysis in different geometries, we offer a comprehensive range of special strain gauges for residual stress analysis, crack propagation and challenging installation requirements. Further useful accessories for a simple and quick installation, documentation and parameterization of your strain gauges are also available.

WHEN TO USE?

Use strain gauge technology if you are looking for an optimal combination of cost-effectiveness and high performance. If the DUT offers a good infrastructure so that electricity and communication interfaces are available at all measurement collection points, the electric strain gauge is often the better choice. In addition, they offer the following advantages:

- Half or full bridge configurations are possible if the loading direction is not multidimensional and known. This gives a very good compensation of temperature induced errors already in the circuit.
- Electrical strain gauges can be manufactured very small and therefore also preferable when installation space is severely limited.

BENEFIT FROM...



Solution-oriented

- Broad range of standard designs with different material adaptations
- Special strain gauges precisely tailored to the respective application
- Custom strain gauges according to your needs

Standard or custom solution, we have the optimal product for you.



Reliable and flexible

- Large selection of strain gauges available directly from stock
- Delivery promises you can rely on
- 24/7 safe and convenient shopping in the HBMshop

Carry out your measuring task with high quality in the given time.



Optimally supported

- Extensive knowledge base and excellent training through HBM Academy
- Worldwide sales network and strain gauge installation service
- Specialized strain gauge designers in Germany

Competent consultancy services for your application.

TYPICAL SETUP / MEASURING CHAIN



Strain gauges

DAQ amplifier QuantumX

catman DAQ software

FIBER BRAGG GRATING TECHNOLOGY: MEASUREMENT USING LIGHT

HBK optical sensors are based on Fiber Bragg Grating (FBG) technology, a suitable and reliable solution for long term structural health monitoring in the most demanding applications. Large structures can be monitored with different types of sensors, connected in line to a single instrument. Strain, temperature, acceleration, displacement tilt and other sensors can be connected in series reducing the network complexity and cabling.

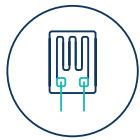
Even in harsh environments and under difficult measurement conditions, FBG sensors enable you to test the fatigue strength of your components and structures. Stress testing, for example, can be conducted even in materials with high levels of strain, and with high numbers of load cycles. You get consistent and accurate test results even in adverse ambient conditions, for example, in high-voltage systems.

The effects of long distances and cable length on the test result can be neglected with optical sensor technology. Even if your data acquisition system is located many kilometers away from the measuring points, you can still rely on high-quality measurement results. The small size and low weight make FBG sensors the ideal choice to maximize installation flexibility in remote sites and spots that are difficult to access. HBK delivers optical sensors with different types of packaging to address a wide range of applications, such as outdoor and concrete.

WHEN TO USE?

1. Use to determine strain, temperature, acceleration, displacement and tilt in components, structures and in environments where conventional technologies have reached their limits.
2. Test structures and materials with high levels of strain, high numbers of load cycles, high electromagnetic noise or in highly explosive environments in a safe and reliable way.
3. Monitor the condition of large structures in harsh environments using different types of sensors, connected in line over long distances and interrogated by a single instrument.

BENEFIT FROM...



Easy to handle

- Compatible with telecom fiber for long-distance measurements
- Simple installation resulting in reduced setup costs
- Robust designs



Configurable

- Selectable wavelengths, cable types, and connectors
- Multiple sensors assembled in arrays with spliced connectors for fast installation
- Bare fiber with multiple FBG



Versatile

- Diverse sensor formats
- High strain and high fatigue resistance
- From simple FBG to complex sensor
- Reinforced or dielectric for applications in different hazardous areas

TYPICAL SETUP / MEASURING CHAIN



Optical sensors

MXFS optical interrogator

Catman software

DYTRAN AND B&K PIEZOELECTRIC ACCELEROMETERS FOR MODAL ANALYSIS OF LARGE STRUCTURES AND MONITORING OF SEISMIC ACTIVITIES

HBK offers high-quality uniaxial and triaxial accelerometers for monitoring small, medium or large structures. Large structures vibrate at lower frequencies and lower amplitudes, and they are harder to excite with sufficient energy to support good coherence between excitation and response sensors. Dytran and B&K high sensitivity, low noise accelerometers assure high level, high quality response signals and integrity of data, even on the largest structures.

SOME EXAMPLES OF ACCELEROMETERS TYPICALLY USED IN CIVIL ENGINEERING APPLICATIONS:

8344 SERIES



Compact seismic CCLD Accelerometer

Suitable for very low vibration measurements especially when the mounting space is limited. Measures from 1.4 G up to 14 G peak acceleration levels over a broad frequency range.

MODEL 3191A1

Ultra-High Sensitivity Seismic IEPE (CCLD) Accelerometer

High low-noise measurement for sub-micro-G resolution with extended low-frequency response ideal for large structure monitoring/test with minimal displacement. 1 G and 0.5 G Peak ranges available.



3233 SERIES

High Sensitivity Triaxial IEPE (CCLD) Accelerometer

3-axis orthogonal accelerometer with small footprint, thru-hole mount, and user-controlled cable exit direction. Available in a broad range from 5000 G Peak to 5 G Peak.



WHEN TO USE?

Use for monitoring vibration and for modal analysis of bridges, large structures, dams, buildings, large pumps, cell towers.

- Your one-stop solution for all data acquisition needs
- Custom cable design is available to fit your application demands
- Plug sensors directly into your HBK DAQ for error-free and seamless operation
- Ease of mind with industry-leading application support

MODEL 4600A1

General Purpose 3 Channel IEPE (CCLD) Data Recorder

To be used with the HBK line of IEPE (CCLD) sensors, versatile data acquisition system and multi-recorder synchronization for acceleration, force, pressure, shock, impulse, etc. sensors. Its rechargeable battery and micro-SD card data storage make it ideal for autonomous and lengthy data acquisition tasks.



7500 SERIES

Ultra Low Noise Variable Capacitance Accelerometers

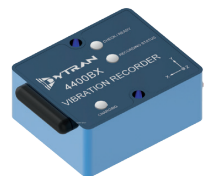
Part of HBK's line of DC response Variable Capacitance accelerometers for challenging applications with static or extremely low-frequency acceleration measurements. Exceptional resolution, differential output, EMI/RFI immunity. Offered in a wide selection of measurement ranges, spanning from 2 G Peak to 400 G Peak.



4400 SERIES

General Purpose Triaxial Acceleration Recorder

Series of standalone acceleration recorders with triaxial variable capacitance accelerometer, rechargeable battery, and micro-SD card. Peak acceleration ranges of 2 G, 19 G, and 200 G available. Ideal for prolonged and isolated data recording in transportation monitoring, delivery service control, general vibration assessments, and studies.



HBK Engineering Services

INSTRUMENTATION REQUIRING CUSTOM MADE SENSORS DEVELOPED FOR A SPECIFIC REQUIREMENT

Sometimes a project requires the ability to design and produce special sensors specifically for that particular type of application. Custom sensors can normally perform functions that are not performed by standard sensors, such as: special sensitivities, particular shapes and fixings, conformation or whatever is of specific interest to the customer.

The components to be instrumented can therefore be part of a structure or elements made 'ad hoc'. The instrumentation then consists of the installation of one or more strain gauge bridges to measure the physical quantities (traction/compression force, bending, torsion) required.

The instrumentation will be preceded by a feasibility study to optimise the specifications required by the customer. A 'working standard' calibration certificate can be produced at the customer's request. The components to be instrumented can be supplied by the customer or manufactured by HBK. The work is carried out by certified HBK personnel, either at HBK or at the customer's facility.



INSTRUMENTATION OF COMPONENTS AND STRUCTURES

As part of the modular concept, HBK with its experienced engineering services department provides a range of services related to the instrumentation of components and structures. These include:

- Engineering analysis for the study of measurement feasibility
- Selection of the best fitting technology and products for the project and customer requirements
- Instrumentation of components and structures at its own laboratories and/or at the customer's premises with resistive or optical strain gauges
- Sensor installation such as accelerometers, displacement transducers, thermocouples, and others on request
- Supply of data acquisition systems
- Procurement, supply and installation of accessories for long term connection and protection of complete sensing networks
- Set-up of instrumentation to optimize data acquisition according to customer requirements
- Monitoring the component/structure behavior during working operation
- Test report
- Data processing support

