

Measurement of mechanical stress

Experimental stress analysis on crane booms

In all industries, especially construction machinery, it is important to analyse the high mechanical stresses to which components are subjected, thus ensuring that they are sufficiently robust. This application report shows how CSM measurement modules accurately measure strain at numerous locations during repeatable experimental analyses on telescopic crane booms.



Background

 Construction machines and their components are tested in special test centers in order to be able to make precise statements about capacity, possible applications and life cycle. Optimized test processes are often essential to maintain operational efficiency. In order to achieve this, a sophisticated process and harmonized measurement technology are required.

In the following example, six telescopic crane booms are tested with strain gauges. Loads are applied to the booms to the point of material fatigue. Simulation data from the development departments is verified with the tests to optimize the material design.

Challenge

 The measurement system requires a high channel count and must be capable of a sufficiently high total sampling rate to ensure that it captures and records every aspect of this destructive test. The data from multiple strain gauges must be acquired synchronously, at a data rate of 200 Hz per channel. The measurement range of the strain gauge and measurement module must be wide enough to acquire momentarily/transient high peaks.



The CSM Measurement Solution

 The time needed for the entire measurement process can be reduced by 50% by implementing a parallel process. While one boom is being tested, sensors and cabling is already being applied to the next (Table 1).

Preparation

In this example a total of 96 measurement channels (18 measurement modules) is used. While 48 channels (9 modules) are used for one test the remaining 9 modules are used to prepare another boom for testing. This way, while one boom is tested the other is being prepared (see Table 1). Conveniently, the measurement is configured once in CSMconfig software and re-used for each test, thus enabling the testing team to save valuable time

The direction and location of the main stress is determined from the simulation data, therefore most of the strain gauges can be applied as single sensors. At the expected neutral position, three strain gauges are applied as a rosette to record the stress profiles. The strain gauges selected have internal temperature compensation.

- ▶ These individual gauges and rosettes are connected to CSM STG6 BK20 /HE measurement modules by a specialized cable. CSM strain-gauge-sensor-cables have an integrated half-bridge completion near the sensor. The full bridge is completed within the CSM measurement module. These specialized cables also enable three-wire connection to minimize possible interference and enable the sensors' temperature compensation. This integration makes the application easy, because no additional measurement equipment is needed.

Preparation	[1]	[2]	[3]	[4]	[5]	[6]	
Testing		[1]	[2]	[3]	[4]	[5]	[6]

[x] = Test specimen

Tab. 1: Parallel sequence of preparation and measurement of individual test specimens

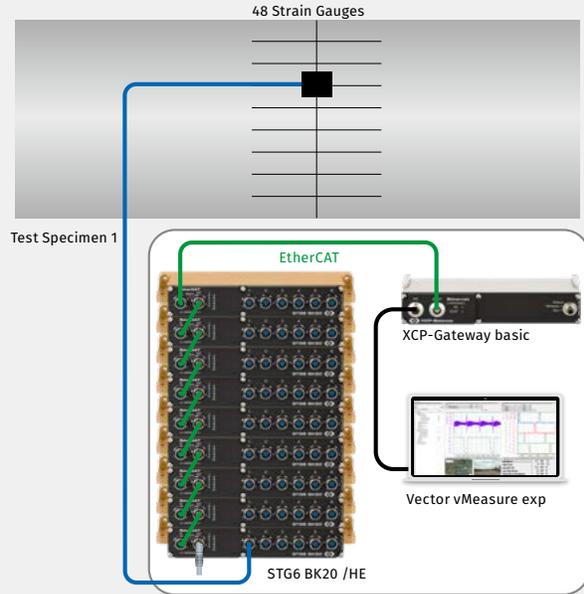


Fig. 3: Preparation: Nine CSM STG6 BK20 /HE measurement modules synchronously collect data from 48 measurement channels. These are configured with CSMconfig.

- ▶ CSM STG6 BK20 /HE strain gauge modules acquire the sensor data from all 48 strain gauges simultaneously. They convert the voltage output from the gauge into a measured strain. Thus the measurement channel sends the measurement value as $\mu\text{m}/\text{m}$, and immediately facilitates the analysis of the data. The measurement data is communicated via high-speed EtherCAT® bus, and all modules are connected to one XCP-Gateway. This Gateway synchronizes all module signals and converts the data to XCP-on-Ethernet for easy connection to Vector's vMeasure exp (or CANape) software.

The Transport

- ▶ After applying all the strain gauge sensors and cables, the crane boom is transported to an open space for testing. CSM STG6 BK20 /HE strain gauge modules are compact and easy to handle, so that they are transported easily with the device under test. In the test area the measurement modules are conveniently

mounted in a suitable device so that they are ready for immediate use. Because in this example the Harsh Environment variant of the modules is used, which were designed for demanding use in all conditions, no extensive weather protection is necessary.

The Test

- ▶ The test specimen is clamped in position at one end, the other end is inserted into a special rig, which is lifted by a crane to induce the load. The acting force is measured during loading with a load cell. The test is performed by lifting the end of the test device until material failure.
- ▶ When one boom is in place for testing, the next boom is being prepared. After the test has been completed, the modules are removed and available to prepare another boom. This provides for a seamless process and improves efficiency of the test facility.

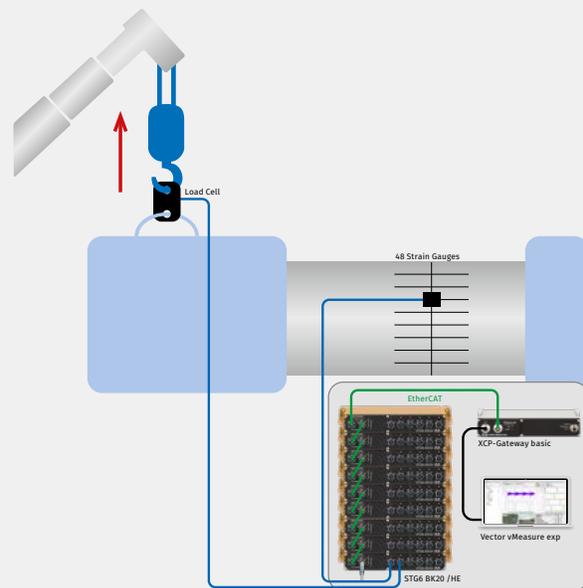


Fig. 4: The measurement modules are transported to the test area with the test specimen. Here, the test specimen is fixed on one side and the desired load is applied by lifting on the other end.

Benefits

 CSM's STG6 BK20 /HE strain gauge measurement modules enable a parallel process for preparation and testing due to their compact and weather-resistant design. They can be easily transported to the instrumented test specimen. They ensure a smooth process because they are preconfigured in CSMconfig software, and the sensor cables simply plug in to the designated BNC connector on the face of the module.

Signals from all 48 strain gauges can be acquired fast and synchronously. The high bandwidth of EtherCAT® means all measurement points can be recorded time-synchronously, with data rates from a few Hz to 20 kHz per channel.

By implementing an efficient process, supported by CSM's software and compact and robust measurement technology, the test team is able to carry out the required tests quickly and accurately. The empirical data obtained also helps verify and update the original design simulations.

Featured Products

XCP-Gateway Series

CSM's XCP-Gateway Series protocol converters were specially developed for CSM EtherCAT® measurement modules and for measurement tasks with multiple measurement channels and high measurement data rates. The XCP-Gateway is available in "Basic" and "pro" versions. The "pro" version has two CAN interfaces via which CAN-based CSM measurement modules can be connected and integrated into the XCP-on-Ethernet measurement data protocol. In the "pro" version, temperature data from the HV Breakout Modules can also be transferred directly via EtherCAT®.



STG6 BK20 (ECAT STGMM 6)

Measuring tasks with strain gauges can be easily performed with the STG6 BK20 measurement module. With six time-synchronous strain gauge inputs for quarter-, half- and full bridges and measurement data rates from 1 Hz to 20 kHz per channel, the STG6 BK20 is also suitable for stress analyses with many points of measurement. Thanks to EtherCAT®, even large measurement networks with distances of up to 100 m between individual measurement modules can be easily set up.



CSM provides you with comprehensive complete packages consisting of measuring modules, sensors, connecting cables and software - customized to your individual needs.

Further information on our products are available on our website at www.csmproductsinc.com or via e-mail info@csmproductsinc.com.



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