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BRIMOS®
Bridge Monitoring System

Cable Assessment
with BRIMOS®

BRIMOS® Cable Assessment

BRIMOS® – Bridge Monitoring System

“from vibration to information”

The increasing number of external pre-stressed elements in modern structures as well as the rehabilitation or reinforcement of existing bridges with this technology raises the question for a technically and economically useful check of effective cable forces or their chronological development. Principally a control of the force with a new application of the pre-stressing jack is possible, but this check is connected with a great logistic, time and therefore also financial expenditure.

Furthermore there is the danger that unintended damages at the cables are caused. For this reason modern, non-destructive procedures are required. Therefore methods such as Ambient Vibration Monitoring are predestined since it enables a quick, flexible and safe determination of the cable force.

The determination of effective cable and tendon forces based on vibration measurement has become a widely known and accepted approach. This means, that there is a proximate correlation between eigenfrequencies and tension forces (comparable to a guitar string, whose tone pitch depends on its tension force).

The exact knowledge of tendon and cable forces is an indispensable requirement during the various construction phases as well as for condition assessment (e. g. cable stayed bridges).

VCE’s methodology, extracting both decisive parameters – the cable’s bending stiffness as well as the so called vibration length – has reached technical maturity.

In the course of numerous projects – completed using BRIMOS® – specific problems concerning cables could be solved.

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BRIDGE MONITORING SYSTEM

Rosen Bridge Tulln, Austria

Cable sensor

Vršovice, Czech Republic

Measurement Technology

Brimos-Recorder®

Dynamic, high-precision monitoring

The BRIMOS-Recorder® monitors ambient vibration and allows acquiring knowledge on the current condition of the examined structure very quickly. The vibration signal is measured in three dimensions with high precision and is saved on the internal data loggers for further assessment.

“All-in-one” solution

Our BRIMOS-Recorder® represents an entirely new conception in compact monitoring and assessment equipment. The main innovation of our development is the design as “all-in-one” equipment containing all required component parts as well as a simplified and very user-friendly operating concept.

Reliable data acquisition

The BRIMOS-Recorder® provides reliable data acquisition of the highest quality. It has the added convenience and flexibility that today’s monitoring technology offers. Thus it has a high value for the interpretation by structural engineers.

Technical Data

- → Size: 390 mm x 245 mm x 170 mm
- → Ultra-low-power CPU
- → Linux operating system
- → Industrial Harddisc
- → 12 V/10 Ah rechargeable battery
- → Resolution: 16 bit with 1 kHz sampling rate
- → Extended temperature range: -30°C up to +60°C
- → 100 MBit Ethernet-connection
- → GARMIN-GPS receiver connection
- → GPRS-Modem (opt.)

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Equipment


Donaustadt Bridge, Austria


Gersbachtalbrücke, Germany


Cable assessment

Measurement Procedure

Our measurement services inlclude:

- → Site visit of an experienced VCE engineer for the measurements.
- → BRIMOS®-Recorder for the measurements.
- → Short visual inspection of the cables by the VCE engineer.
- → Performance of vibration measurements on each single cable with a sampling rate of 500 Hz in the total length of 330 sec.
- → Quality check of the measurement data on site.
- → Data analysis in the home office with the BRIMOS® software
- → Determination of the cable forces, cable bending stiffness and cable damping.
- → Preparation and submission of a detail assessment report with the determined dynamic properties and cable forces for all cables.

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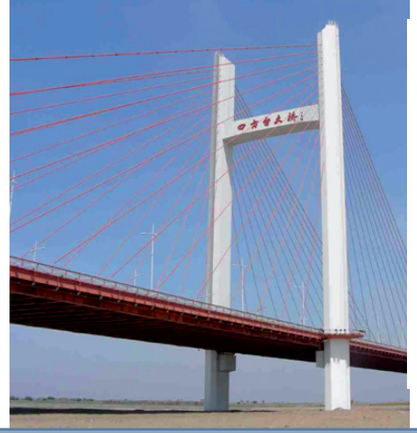
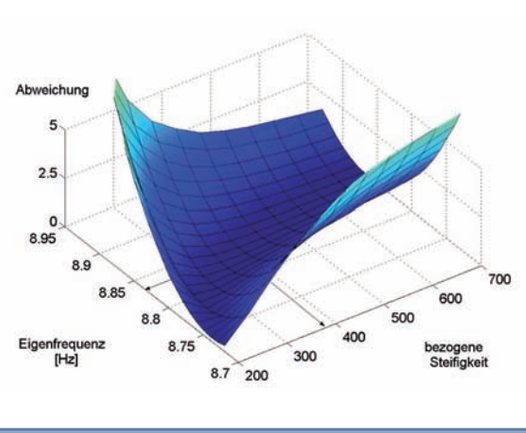
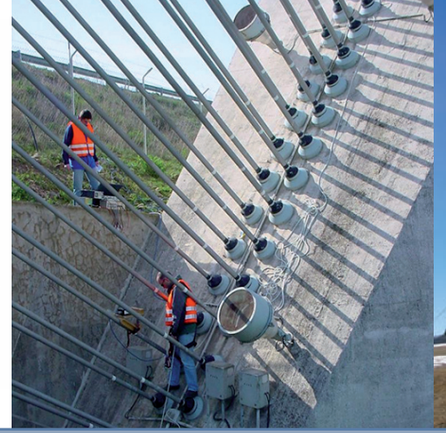


Songhua, China



Results of analysis



Alzado, Spain

Schöckl, Austria

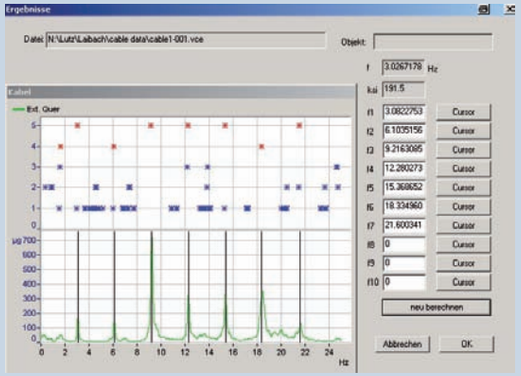
Data Analysis

In principal a control of the acting cable force with a new application of the prestressing jack is possible, but this check is connected with a great logistic, time and therefore also financial expenditure. Furthermore there is the danger that unintended damages at the cables are caused. For this reason modern, non-destructive procedures present itself which are based on the dynamic characteristic.
The evaluation of the cable forces is done directly through the measurements of the fundamental vibration frequencies, as well as of the interval between the frequencies of consecutive modes.
For the calculation of the exact cable force the determination of the basic and higher vibration frequencies is necessary. A linear relation between the basic and higher order of natural frequencies is only valid for a wire without sag and bending stiffness. This theoretical case is called “string wire”. In such a string wire there is a harmonic succession of every mode shape starting from the first up the to very high natural frequencies.
A real cable brings up a deviation from this ideal case in the higher modes, since the bending stiffness causes an increase of natural frequencies in the higher modes. For an accurate hanger force measurement, this effect must be considered. From the measurement data the actual hanger force can be calculated by the BRIMOS® software.

The only input needed for this analysis is the hanger geometry and the hanger’s properties. The determination of the natural frequencies, the bending stiffness, the damping values and the hanger forces is done full automatic by the BRIMOS® Software.
The identified eigegenfrequency f1 is a function of the effective hanger force, the length, the mass and the stiffness of the hanger.

$$f_k = \frac{k}{2l}\cdot\sqrt{\frac{N}{m}}\cdot\left(1+\frac{2}{\xi}+\left(4+\frac{k^2\pi^2}{2}\right)\cdot\frac{1}{\xi^2}\right)$$

f_k .... Frequency of the order k
N .... Hanger force
m .... Mass of the hanger per meter
l .... Length of the hanger between the nodes of the relevant mode shape
ξ .... Nondimensional hanger stiffness



The results of the analysis are:

- → Natural frequencies of the cables
- → Cable forces
- → Cable damping
- → Cable stiffness
- → Susceptibility to vibrations (wind-rain induced vibrations, parametric excitation by thebridge deck)

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Svinesund, Norway/Sweden


Tete Bridge, Moçambic


Maoloshi Bridge, Taiwan


Strelasund, Germany

Reference Projects

Experience

BRIMOS® is a development based on several research projects startet in 1995. More than 50 cable supported structures with more then 5000 cables in total have been assessed up to date. The gained experience has been incorporated in the assessment procedure.

Typical Applications

The BRIMOS® technology is typically applied to cables of:

→ Stay Cable Bridges
→ Suspension Bridges
→ Cable supported Towers
→ External Tendons
→ Temporary Tendons

For further information see:
www.brimos.com
www.vce.at