Europabrücke - Austria

Project Description:

Bridges are ageing and traffic is growing, which creates a demand for accurate fatigue life assessment. The Europabrücke – a well known Austrian steel bridge near Innsbruck, opened in 1963 - is one of the main alpine north-south routes for urban and freight traffic. A long-term preoccupation of VCE with BRIMOS® (BRIdge MOnitoring System) on the Europabrücke (since 1997) and the assessed prevailing vibration intensities with regard to fatigue problems and possible damage led to the installation of a permanent measuring system in 2003. Today's monitoring abilities enable us to measure performance precisely. High-precision sensor data of accelerations, velocities, displacements in dependence of separately registered wind and temperature data and their implementation into analytical calculation provide the possibility to realize lifetime considerations, which are of eminent importance for bridge operators.

Europabrücke, Innsbruck, Austria

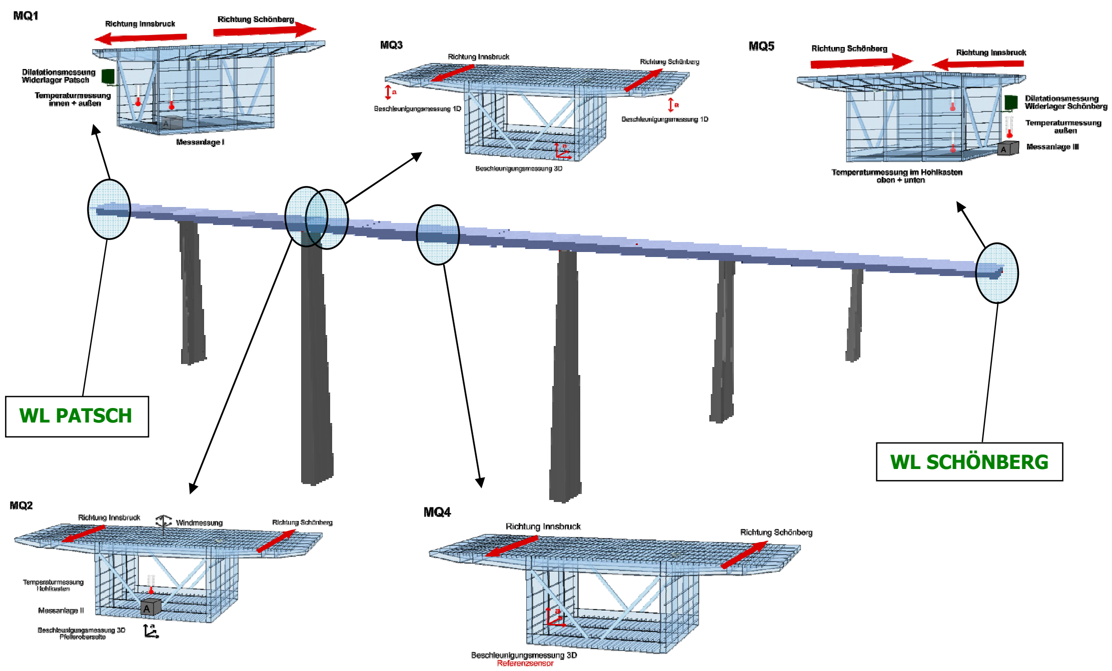
Description of Structure & Monitoring System

Previous measurements at the Europabrücke matched very well with the comparative analytical calculations, but they also exhibited the remarkable loading impact. Currently the bridge is stressed by more than 30000 motor vehicles per day (approximately 20% freight traffic). The superstructure is represented by a steel box girder (width = 10m; variable height along the bridge-length 4,70 – 7,70 m) and an orthotropic deck and bottom plate. This motorway bridge with six spans differing in their length (longest span 198m, supported by piers with an elevation of 190m) and a total length of 657 m comprises six lanes, three for each direction distributed on a width of almost 25 meters.

Quick Facts:

- **Name and Location:** Europabrücke, Innsbruck, Austria
- **Operator:** ASAG (Alpenstrassen AG), Austria
- **Structure category:** large span bridge
- **Spans:** 6 spans: 81/ 108/ 198/ 108/ 81/ 81 m
- **Structural system:** Steel box girder with orthotropic deck and concrete columns
- **Start of SHM:** May, 1998
- **Number of sensors installed:** 24
- **Instrumentation design by:** VCE, Vienna Consulting Engineers, Austria

The monitoring system itself consists of 24 measuring channels (sampling rate 100 Hz) representing the main span's, the pier's and the cantilever's accelerations, the abutment's dilatation, wind speed and direction, and temperatures at several locations.



Purpose of Inspection:

The superior goal is to determine the relation between the randomly induced traffic loads (vehicles per day) and the ***fatigue***-relevant, dynamic response of the structure. As life-time predictions in modern standards depend on lots of assumptions, the emphasis is to replace all these guesstimates by measurements. In that context it is going to be focused on three ranges:

- Global behavior in dependence of all relevant loading cases
- Cross-sectional behavior under special consideration of the cantilever regions
- Local systems analyzing the interaction between tires and the beam-slab connections

In each of these levels of analysis the consumption of the structure's overall-capacity per year is to be determined.

Additionally to fatigue assessment, new compensation methods for ***assessment & compensation of environmental conditions*** (temperature, additional mass loading,…) in frequency analyses are developed. This opens new possibilities for structural management and lifetime prediction as well as for more accurate damage detection.

Sensor Details:

Type of sensors	Number	Location
Displacement sensors	2	at both abutments
1D-acceleration transducers	3	at the cross section's cantilevers
3D-acceleration transducers	3	orthotropic bottom plate
Wind sensors	1	5m above the road surface
Temperature sensors	7	inside & outside the box girder

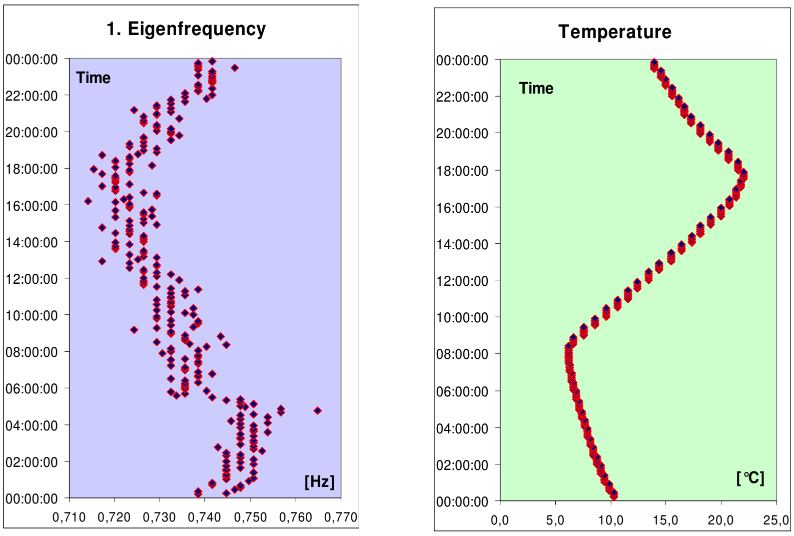
Measurement Equipment and Data Management:

Type of system	Data Management
PC & remote access - based measuring system	▪ automatic report generating at the end of each week ▪ Storage in a long term data base on site ▪ More detailed analysis (statistics, frequency analysis…) and graphical presentation and documentation in office ▪ notification via modem about the successful operation of the measuring system

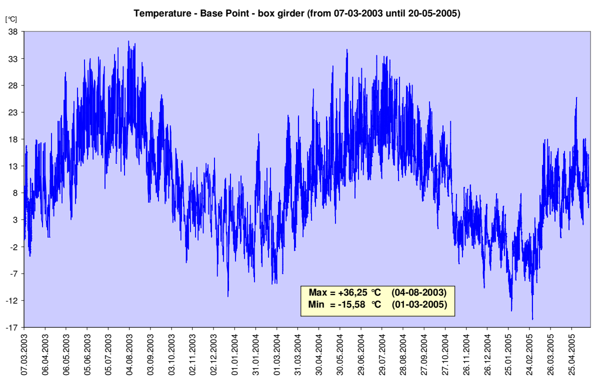
Data Analysis Procedures:

Type of analysis	Software	Additional features
Ambient vibration monitoring, Fatigue assessment based on rainflow analysis & statistics, assessment & compensation of environmental conditions, damage detection and lifetime calculations	Self made software, RFEM	▪ no expert system

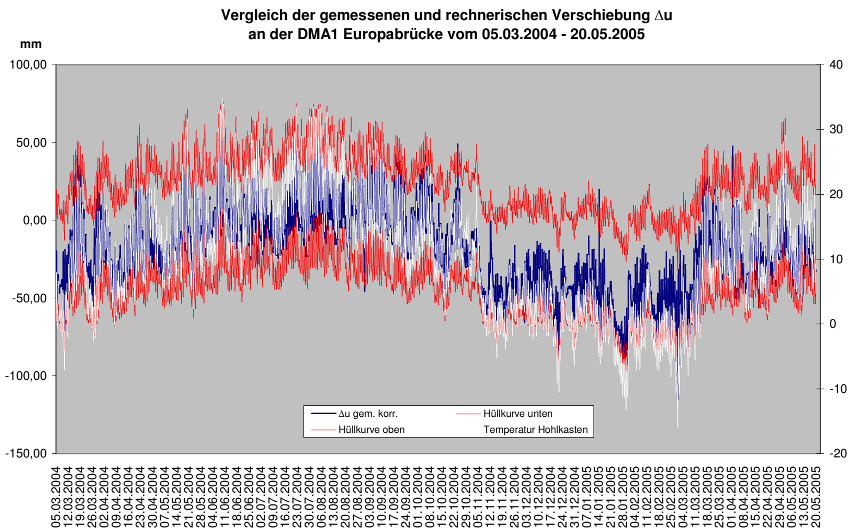
Examples of Outcomes
- Assessment & Compensation of Environmental Conditions



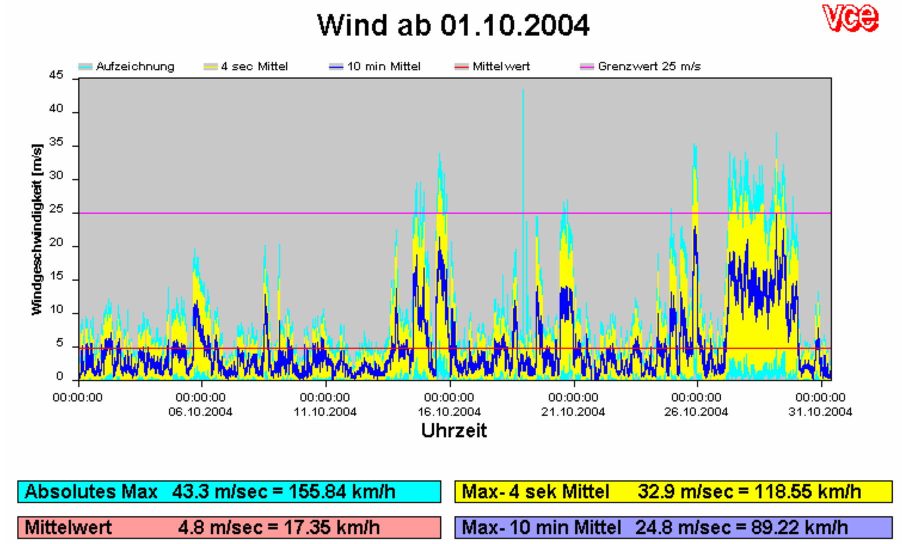
Pattern of the main span's stiffness and its obvious dependency on temperature (daily cycle)



Pattern of temperature at the bridge's basing point (assessment period 2 ½ years)

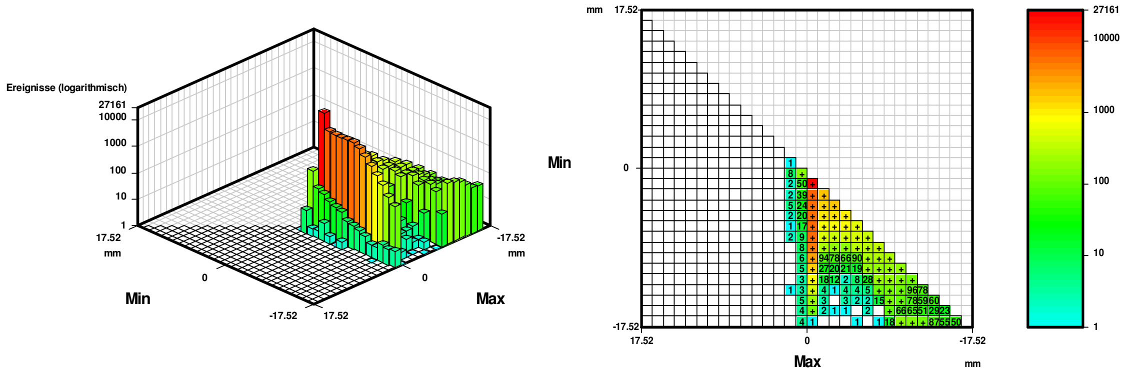


Comparison of assessed & expected horizontal bridge deformations in dependence of temperature

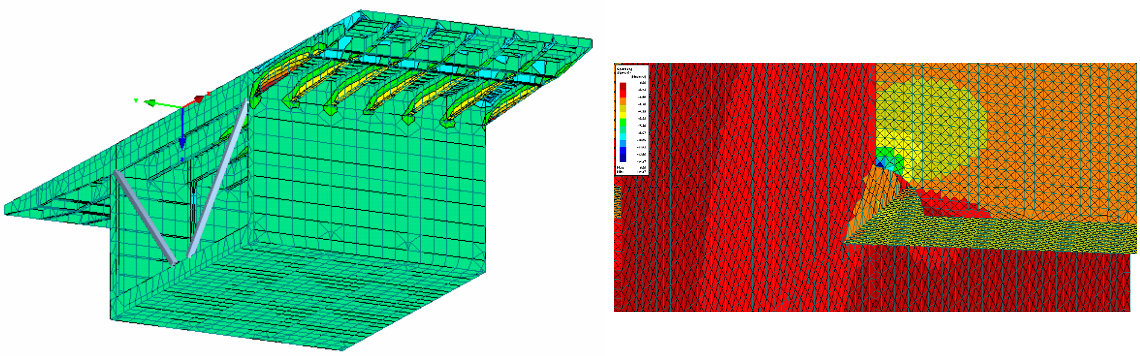


Wind velocity-analysis for a certain month

In each of the already described levels of **fatigue analysis** performed by means of Rainflow-Counting, damage-accumulation, global and local Finite Element Analysis & statistical consideration. The detailed knowledge about the progression of the prevailing traffic from the very beginning up to these days and the implementation of published future trend studies for the next ten years can be used for an extrapolation of the measured impact for the whole lifetime.



Rainflow Matrices for counting of recurring fatigue-relavant impact cycles



Damage assessment via implementation of measurements into Finite Element-Models

References

1. Wenzel, H., and D. Pichler. 2005. "Ambient Vibration Monitoring," *J. Wiley and Sons Ltd.,* Chichester - England, ISBN 0470024305
2. Veit R., H. Wenzel and J. Fink. 2005. "Measurement data based lifetime-estimation of the Europabrücke due to traffic loading - a three level approach", In International Conference of the International Institute of Welding. Prague.
3. H. Wenzel, R. Veit, H. Tanaka.: "Damage detection after condition compensation in frequency analyses" in "Proceedings of the 5th International Workshop on Structural Health Monitoring", Stanford, September 2005

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