

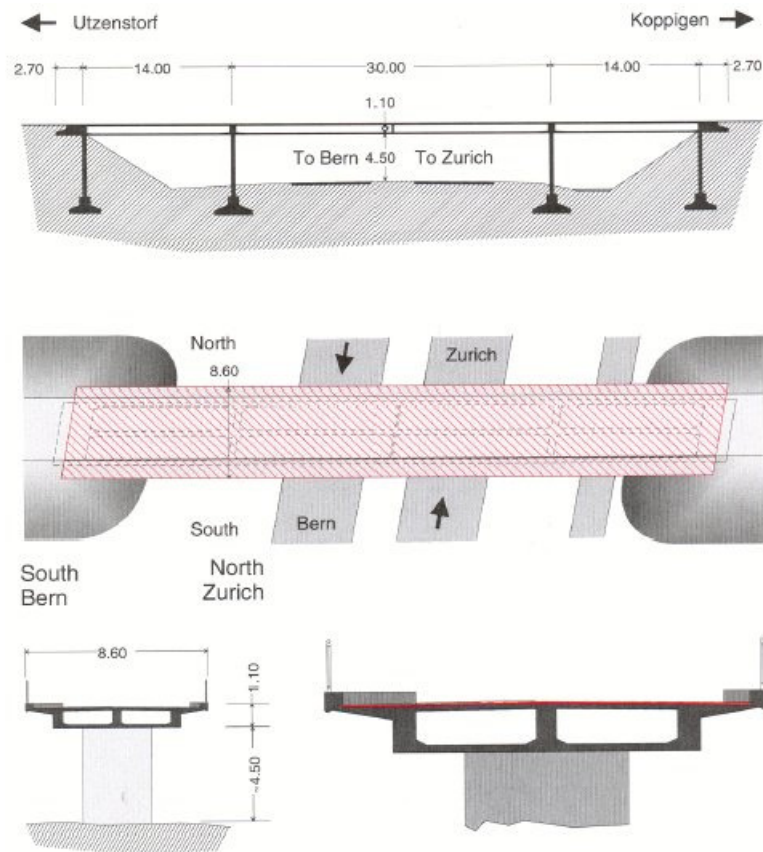
Bridge Z24 - Switzerland

Project Description:

The Z24 bridge, built between 1961 and 1963, spanned the A1 Bern-Zurich motorway and linked Koppigen with Utzenstorf. The three-span structure with spans of approximately 14, 30 and 14 m crossed the A1 at a slightly oblique angle. The superstructure consisted of a two-cell closed box girder with tendons in the three webs. The condition of the bridge was relatively good but the bridge had to be demolished to allow the construction of new railway tracks.

Within the SIMCES project the influence of the environment on the dynamic characteristics (natural frequencies and mode shapes) was investigated as well as the changes of the dynamic characteristics due to progressive damage tests (PDT).

It was the aim to provide an experimental basis for a feasibility proof of the SHM method. Vibration measurements prior to and after a damage scenario should allow conclusions to be drawn about the possibility of identifying damage from changes in dynamic characteristics.



Z24 Bridge, Switzerland



Z24 Bridge, Koppigen-Utzenstorf, Switzerland

Quick Facts:

- **Name and Location:** Z24 Bridge, Koppigen-Utzenstorf, Switzerland
- **Owner:** Road department of the canton of Bern
- **Structure category:** medium span bridge
- **Spans:** 3 spans: 14 / 30 / 14 m
- **Structural system:** Prestressed concrete, with two-cell closed box girder, two concrete diaphragms as main piers and concrete columns at abutments
- **Start of SHM:** August and September, 1998
- **Number of sensors installed:** (15+2) x 9 setups + 3 reference channels
- **Instrumentation design by:** EMPA

Description of Structure:

The three-span structure had a total length of 58 m, subdivided in three spans of 14, 30 and 14 m, respectively. It crossed the A1 at a slightly oblique angle. The superstructure consisted of a two-cell closed box girder with tendons in the three webs. More tendons were allocated over the main piers than in the middle of the spans.

Both main piers were built as concrete diaphragms, fully connected with the superstructure. The three abutment columns were pinned at both ends.

To protect the anchor heads, both ends of the bridge deck were extended.

Purpose of Inspection:

The purpose of the SIMCES project was to prove the feasibility of assessing the integrity of civil structures by means of evaluating their vibration. Several damage scenarios were applied and the resulting changes in dynamic characteristics were recorded and used to detect and identify the corresponding structural damage. Full-scale ambient (AVT) as well as forced vibrations (FVT) were carried out.

More information on <http://www.kuleuven.ac.be/bwm/SIMCES.htm>

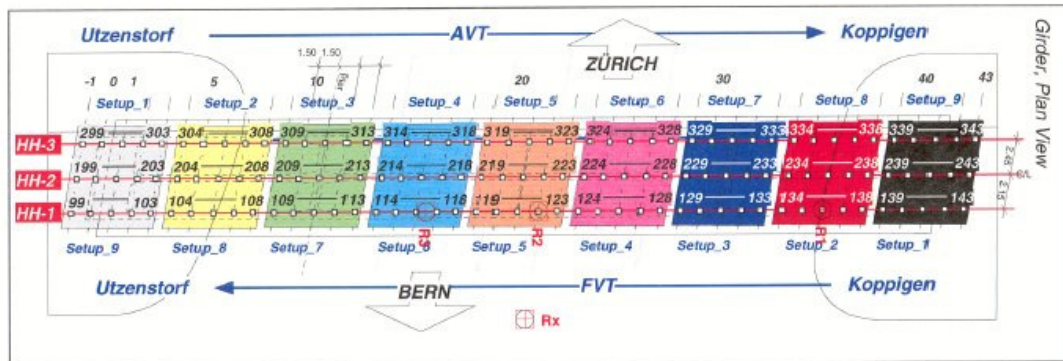
One way to solve the inverse problem is by Finite Element model updating. As an example, the damage scenario consisting in the lowering of the main pier at the right-hand side over 95 mm, which induced cracks in the main girder above this pier, is investigated. It was the aim to identify the stiffness reduction of the girder by updating the FE model using the experimental dynamic characteristics. Only the AVT results were used in the updating process.

Sensor Details (AVT tests):

Type of sensors, Number and Location

Accelerometers:

15 (on the bridge deck)
+ 2 (on a pier)
+ 3 reference channels } X 9 setups



Measurement grid on bridge deck

Measurement Equipment and Data Management:

| Type of system | Data Management |
|-----------------------------|---|
| PC based measurement system | <ul style="list-style-type: none"> data pre-analysis (data reduction and frequency analysis) on site raw data: available on http://www.kuleuven.ac.be/bwm/IMAC/index.html main analysis: performed by different partners of SIMCES project. KUL results: available in office. graphical presentation and documentation on http://www.kuleuven.ac.be/bwm/SIMCES.htm and http://www.kuleuven.ac.be/bwm/Z24/index.html |

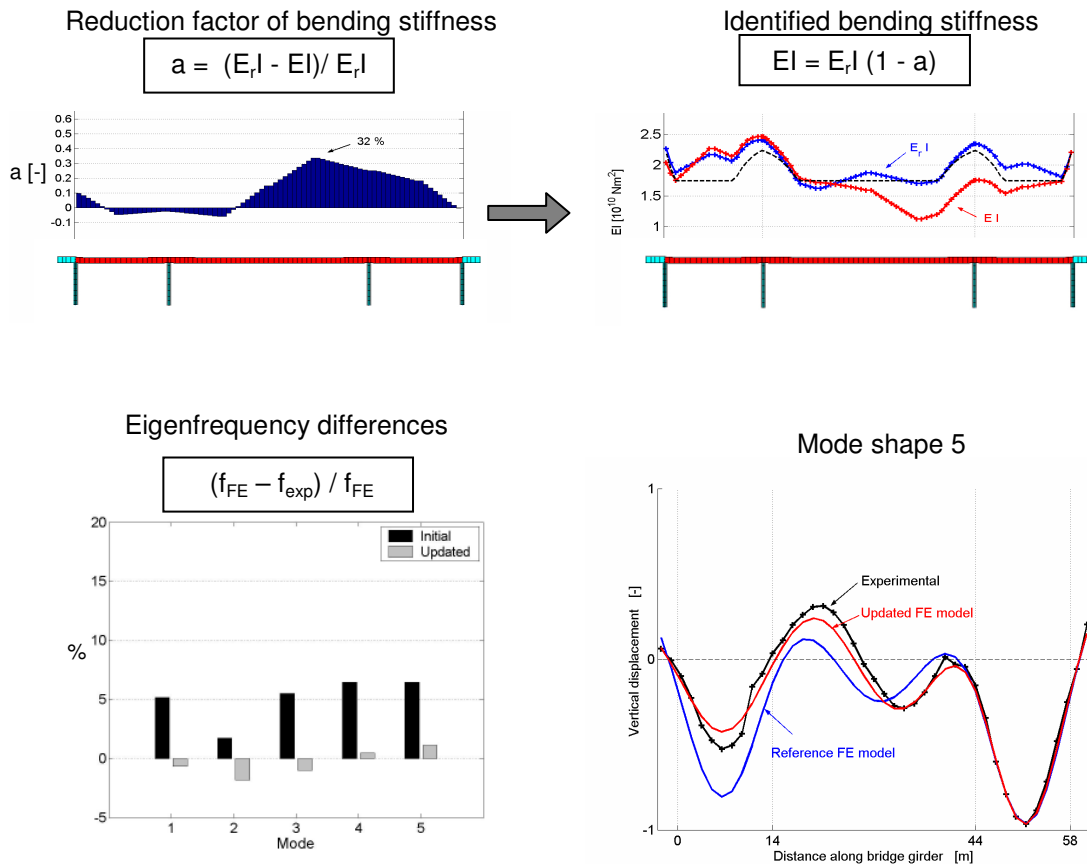
Data Analysis Procedures:

| Type of analysis | Software | Additional features |
|--|---|--|
| Dynamics, experimental modal analysis, damage indicators | <p><i>System identification:</i> Stochastic Subspace Identification technique [1]</p> <p><i>FE model updating:</i> Own developed software (in Matlab) [2]</p> | <ul style="list-style-type: none"> output-only system identification in time domain natural frequencies and mode shapes are used |

Examples of Outcomes:

The box bridge is modeled by a beam model with equivalent stiffness properties. The damage is represented by a reduction in bending and torsional stiffness of the constituting beam elements.

A globally realistic damage pattern is identified for the bending and the torsional stiffness with the FE model updating method. A good correlation between the experimental and the updated numerical modal data is obtained.



Top: Identified relative reduction and resulting bending stiffness of main girder
Bottom: Discrepancies between numerical and experimental modal data

Benefits of Using SHM Technologies in the Project:

Based on the experimental modal characteristics of the bridge, the applied damage pattern could be identified through an inverse analysis. The realistic result proves the performance of the nondestructive vibration-based damage identification method.

References:

- [1] Peeters B. and De Roeck G., Reference-based stochastic subspace identification for output-only modal analysis. *Mechanical Systems and Signal Processing*, **6**(3), 855-878, 1999.
- [2] Teughels A. and De Roeck G., Structural damage identification of the highway bridge Z24 by FE model updating. *Journal of Sound and Vibration*, accepted for publication, 2003, http://www.kuleuven.ac.be/bwm/pub_pap.htm
- [3] EMPA work package, *Brite-Euram Project SIMCES, Tasks A1 and A2: Long term Monitoring and Bridge Tests*. Technical report, Dübendorf, Switzerland, 1999.

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