

Geodetic monitoring and deformation analysis of a vertical lift bridge



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Talk Outline

- Introduction
- Monitoring concept
- Data analysis
- Summary and outlook

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Introduction

The Rethe vertical lift bridge in Hamburg

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Introduction

- Construction of a new bridge next to the current location
- Monitoring of the typical behaviour of the old bridge
- Detection of deformation behaviour changes during the construction process in order to guarantee **functionality and safety**
- Deformation model
 - *Dynamic model*:
Change of the construction's state over time depending on causal variables (e.g. temperature, traffic)

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Monitoring concept

Deformations ? Causal variables

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Monitoring concept

Sensor communication and data management

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Monitoring concept Realisation

- Calibration of sensors at the Geodetic Institute
- Testing of sensor communication system and data base
- Long term measurements (~2 weeks)
- Short term measurements (2 days)
- 3D-model with laserscanner (2 days)
- Data analysis

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Data analysis of long term measurements

- Introduction of a common time reference to all data
- Data gaps were interpolated and 15s intervals established
- Low pass filtering in order to reduce noise
- Elimination of linear trends
- Application of time series analysis tools in time and frequency domain

→ Identification of causal variables in deformation measurements

Source: Welsch et al 2000

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Data analysis of long term measurements Tilt

- Long term measurements for two weeks
- Periodogram
- Analysis of tide and temperature impact on tilt data
- Cross correlation between tilt and cause variables temperature and tide → temperature significant

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Data analysis of long term measurements Tilt

- Goal: Tilt of tower in mgon per °C

→ Linear regression between tilt and temperature

- Regression: $y = b_0 + b_1 \cdot (x - j_x) + u$
- Significant parameters
 - Zero offset: $b_0 = -30.1044 \text{ mgon}$
 - Slope: $b_1 = 3.1124 \text{ mgon/}^\circ\text{C}$
- Significant stability index: $B = 0.42$
- Increasing temperature → northern tower tilts south

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Data analysis of long term measurements GPS

- Long term measurement for two weeks
 - Interval: 15 s
 - Position determination deploying Trimble Total Control (TTC)
- Static solution
 - Entire measurement period
 - Daily
- Kinematic solution On The Fly (OTF)

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Data analysis of long term measurements GPS

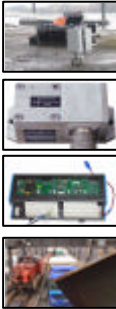
- Kinematic solution
- Dominant frequency obtained from periodogram

- → Daily period due to temperature
- Harmonics appear due to a not pure sine function of the northing component

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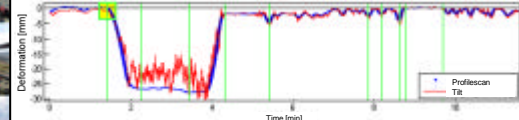
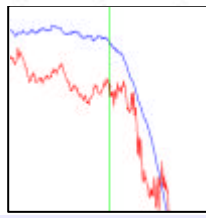

Data analysis of short term measurements High frequency measurements

- Laserscanner profiles under lift section
- Tilt sensors on lift section
- Synchronisation
- Traffic capture with video camera



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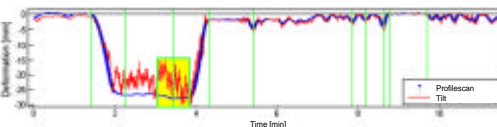
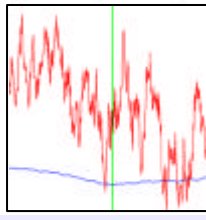

Data analysis of short term measurements High frequency measurements

max. deformation: 0.1 mm

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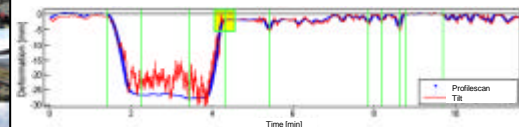
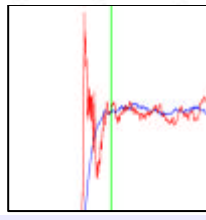

Data analysis of short term measurements High frequency measurements

max. deformation: 27.9 mm

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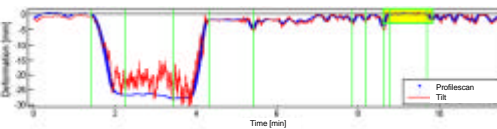
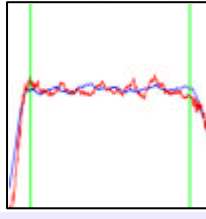

Data analysis of short term measurements High frequency measurements

max. deformation: 2.0 mm

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Data analysis of short term measurements High frequency measurements

Noise level: 0.1 mm

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Summary and Outlook

- Successful implementation of the monitoring concept
 - Typical deformation behaviour of the Rethe vertical lift bridge was determined
- Innovation
 - Sensor communication deploying WLAN
 - Data management with MySQL-data base
 - Laserscanner for determination of high frequency deformations
- Results
 - mm-deformation of towers due to long periodic effects
 - cm-deformation of lift section due to traffic
- Outlook
 - Realisation of data access via internet
 - Detection of exact lifting operation times with GPS

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Thank you for your attention!
Engineering Surveying Project at GIH 2005/2006



from left: Thorsten Strubing, Matthias Fessele, Dipl.-Ing. Hans Neuner, Jens -André Paffenholz, Ilka Rehr, Jan Dirk Wegner, Xiao Ying Cong, Dipl.-Ing. Jürg Grabowski
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