Short-term monitoring of a cable stayed timber foot bridge

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Topics


• The Älvsbacka Bridge
• Structural Health Monitoring
• Installed system
• Installation and tests
• Present and future work

Älvsbacka Bridge

A typical modern Swedish timber bridge made of local spruce and galvanized steel.

- The main beams and pylons vertical sides are protected by wood cladding and the horizontal surfaces are covered with stainless sheet metal.
- Designed for a load of 4 kN/m2.
- The bridge decks total length is 182 m and supported by 20 stay cables, Ø45-80 mm.
- Designed for a minimum life time of 80 years.
- Main inspection every six years.

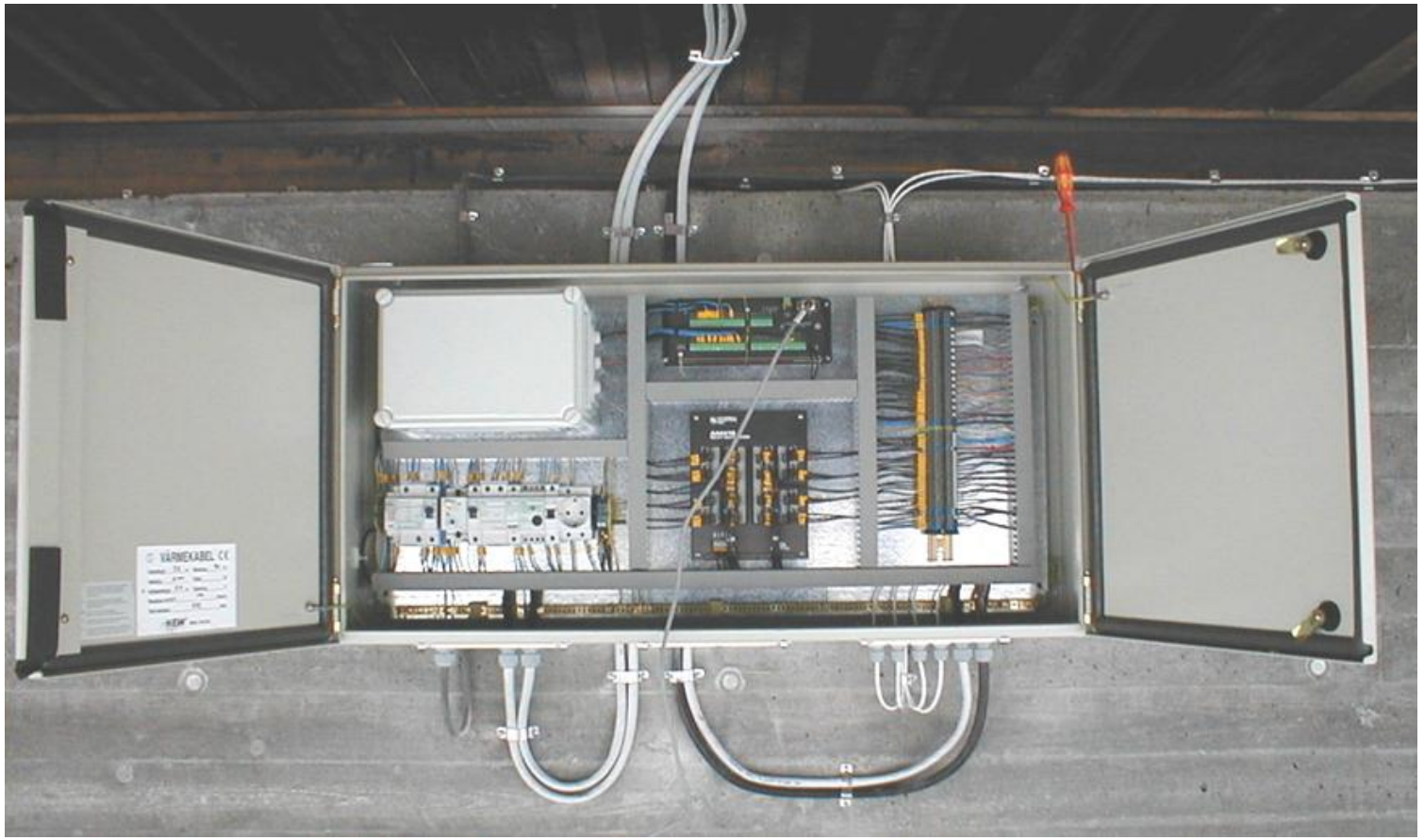
The SHM system on Älvsbacka bridge

The bridge is unique with its long span and narrow bridge deck. The purpose of the SMH system is to measure:

- Deflection in the structure during short and long term.
- Load levels in stay cables for stress conditions
- Influence of weather conditions on the structure
- Structure dynamic characteristics and damping over time
- Moisture content in wood structure

Its a part of the “Sense Smart City”, project in Skellefteå, run by LTU.

Structural Health Monitoring 1.0



Our first installation of a simple monitoring system was back in 1994. It was a static systems with typical sampling rate of 1 sample/h.

- Stressing bar forces.
- Temperature and moisture content in wood.
- Longitudinal displacement of bridge deck .
- Outdoor climate.
- Data logger and GSM connection for data transfer.

Structural Health Monitoring 3.0

This is our first installation of a SHM with:

- wireless accelerometers
- dynamic measurement capability
- GNSS positioning
- Wireless measurement of moisture content in wood.
- Laser based displacement transducers
- Access to SHM system trough Internet.
- Computers at site for data processing.
- Five different time synchronized systems for data processing
- Web camera as a measurement tool

Sensor overview

- Mulle, 3 axis MEMS wireless accelerometers (18).
- Leica GMX 902 with AS10 antennas for GNSS positioning (3).
- OmniSense wireless sensors for temp, RH and WME (9).
- ME Messsysteme GmbH in line tension load cells (5).
- Vaisala VXT 520 weather transmitter (1)
- Micro-Epsilon laser distance sensor optoNCDT (1)

GNSS, Global Navigation Satellite System

- Leica GMX 902 receivers connected to a computer.
- Leica AS10 antennas for GNSS positioning at mid-span, quarter-span and on top of one pylon.
- The antenna on the pylon is used as reference for the two rover antennas at the down stream side of the bridge deck
- Sampling rate 1Hz

Table 1: Existing and proposed GNSS signals [MHz]

System	L1/E1/E2/B1	L2/B2	L5/E5	E6/B3
GPS	1575.42	1227.6	1176.45	
GLONASS	1598.063 - 1605.375 *	1242.938 - 1248.625 *		
Galileo	1575.42		1176.45, 1207.14, 1191.795	1278.75
Compass	1561.098, 1575.42, 1589.742	1207.14	1176.45	1268.52
SBAS	1575.42			
OmniSTAR and CDGPS	1525 - 1560			

In line tension Load cells

Five strain gauge based load cells are used to measure stay cable forces in one corner of the bridge.

- One M80 1000kN
- Three M64 600kN
- One M48 500kN
- One Delphi TopMessage logger with two AVDT analogue modules

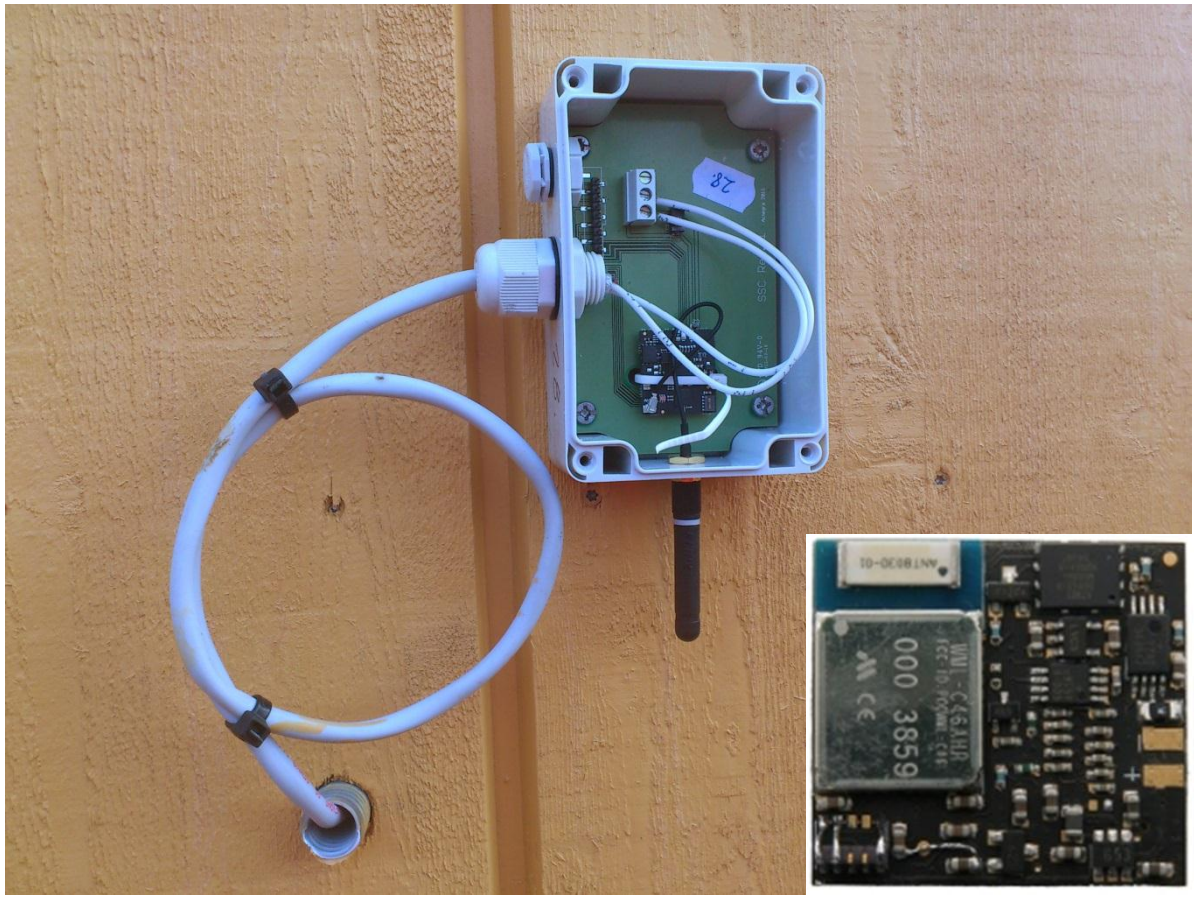
The load cells have 6-wire connection to the logger. The data logger stores data locally on site and it is connected to and controlled trough Internet.

Real time weather data

Weather Transmitter, Vaisala WXT520 on top of pylon. It measures the most essential weather parameters.

- Sampling rate1Hz
- Air temperature
- Relative humidity
- Barometric pressure
- Wind speed and direction
- Rainfall intensity and duration

Wireless 3-axis MEMS accelerometers



- Accelerometers so called “Mulle” sensors
- Range +/- 2G (re-built +/- 8G sensor)
- Cost effective
- Working frequency 868,3 MHz
- Receiver mounted in main cabinet at abutment.
- Remote access trough Internet
- Sample rate 20 Hz, up to 5 kHz is possible
- Wireless data transmission
- Power supply 5 VDC

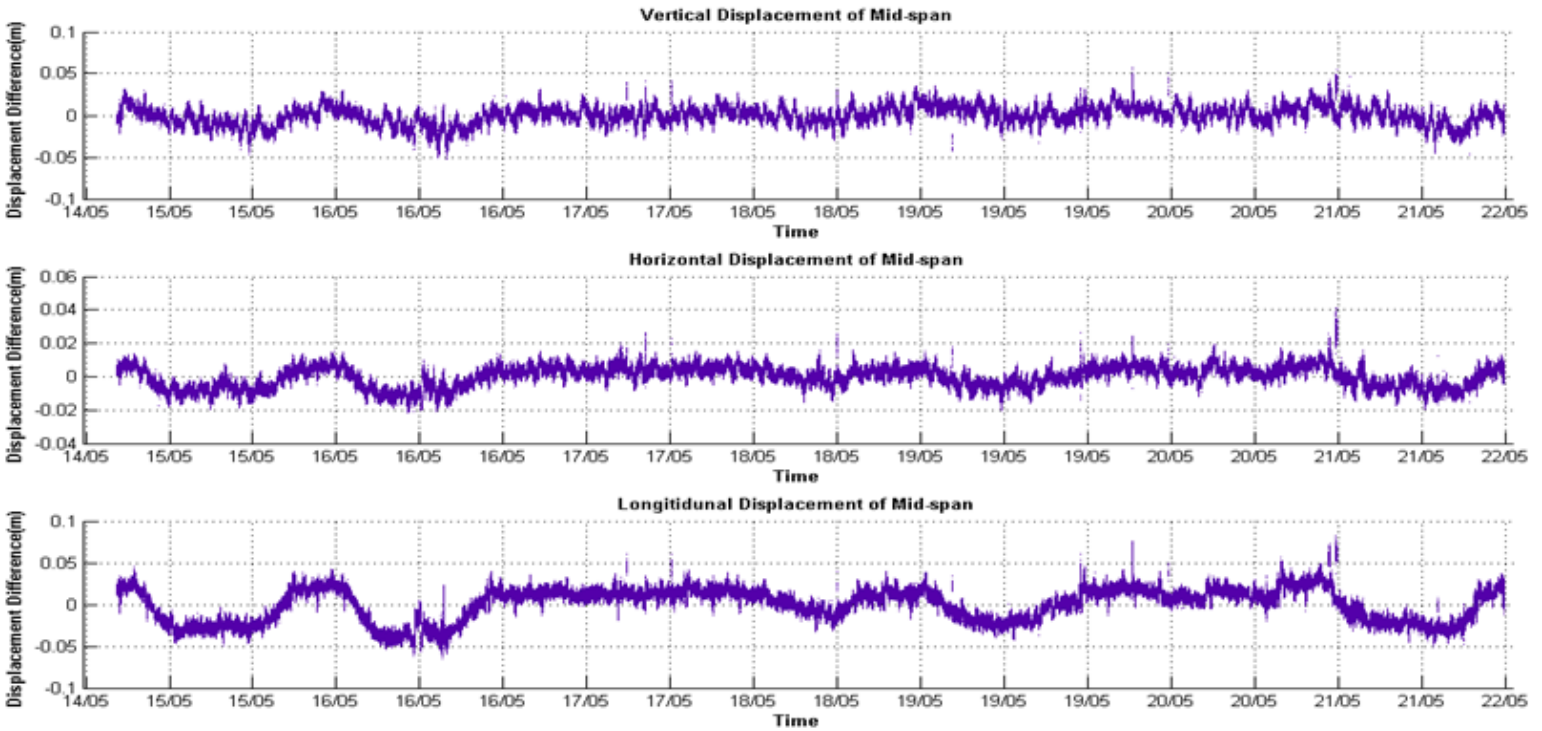
Sampling of sensor data

All SHM equipment is mounted in a metal cabinet on the abutment ,under the bridge deck. Its not a optimal location for the cabinet but the only solution in this case. In the cabinet there are:

- Two computers working synchronized.
- One if the computers is a Network Time Protocol server (NTP).
- Receivers for GNSS, data logger for load cells, Gateway for temp and WMS-sensors, a laptop for the accelerometers and the Internet router
- Heater and two DC power supply units

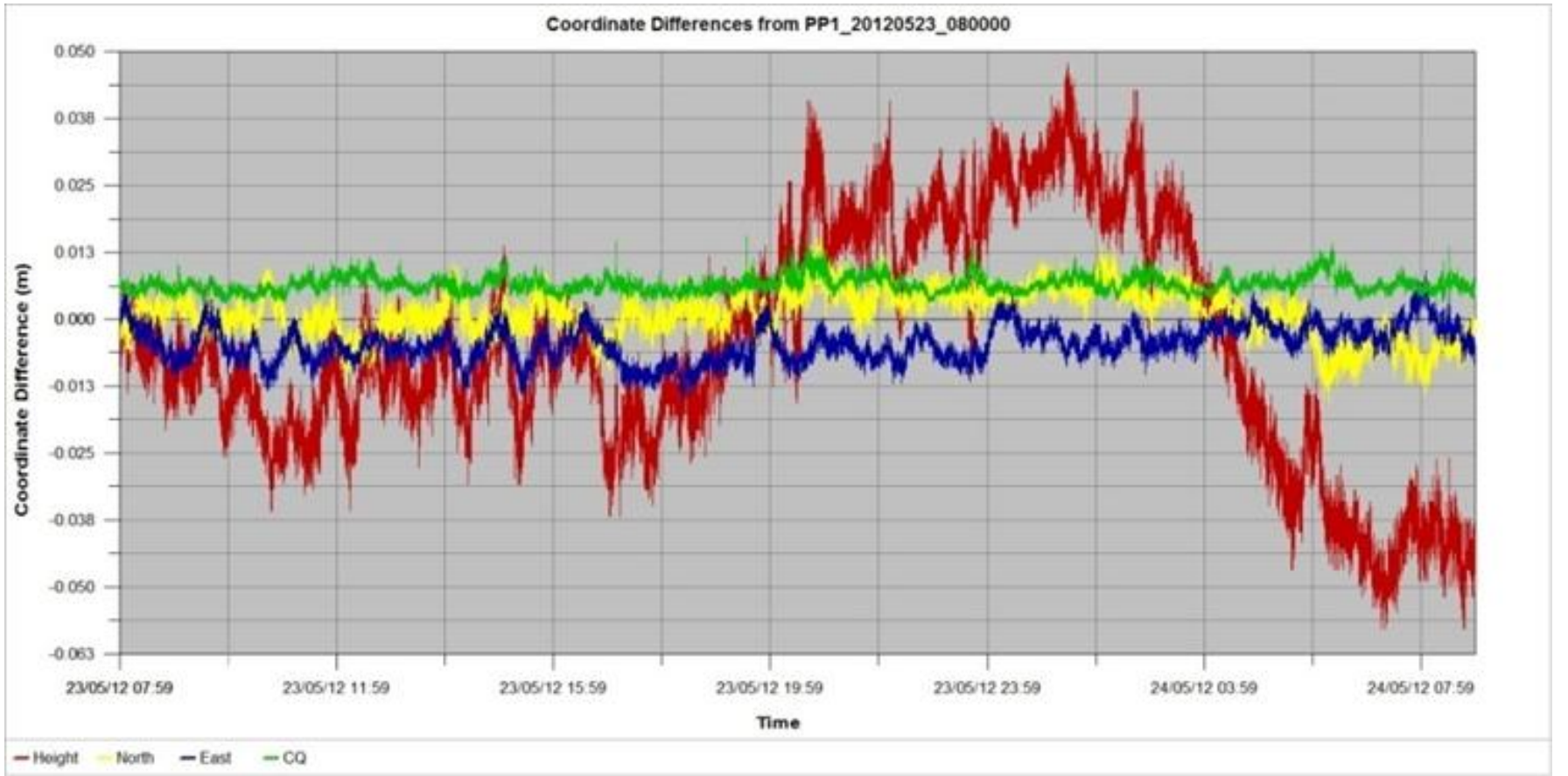
Installation and initial work

A lot of time was spent getting all systems up and running, hopefully working together and at the same time. There where no “plug and play” moments in this case.



- Time synchronization of all measured data with time stamp from the GNNS satellite system.
- Interference with other wireless sensors in a nearby building
- Several tests to tune and calibrate the Accelerometers.
- Several minor tests were performed, one of them was presented here by Robert Kliger, Chalmers University of Technology

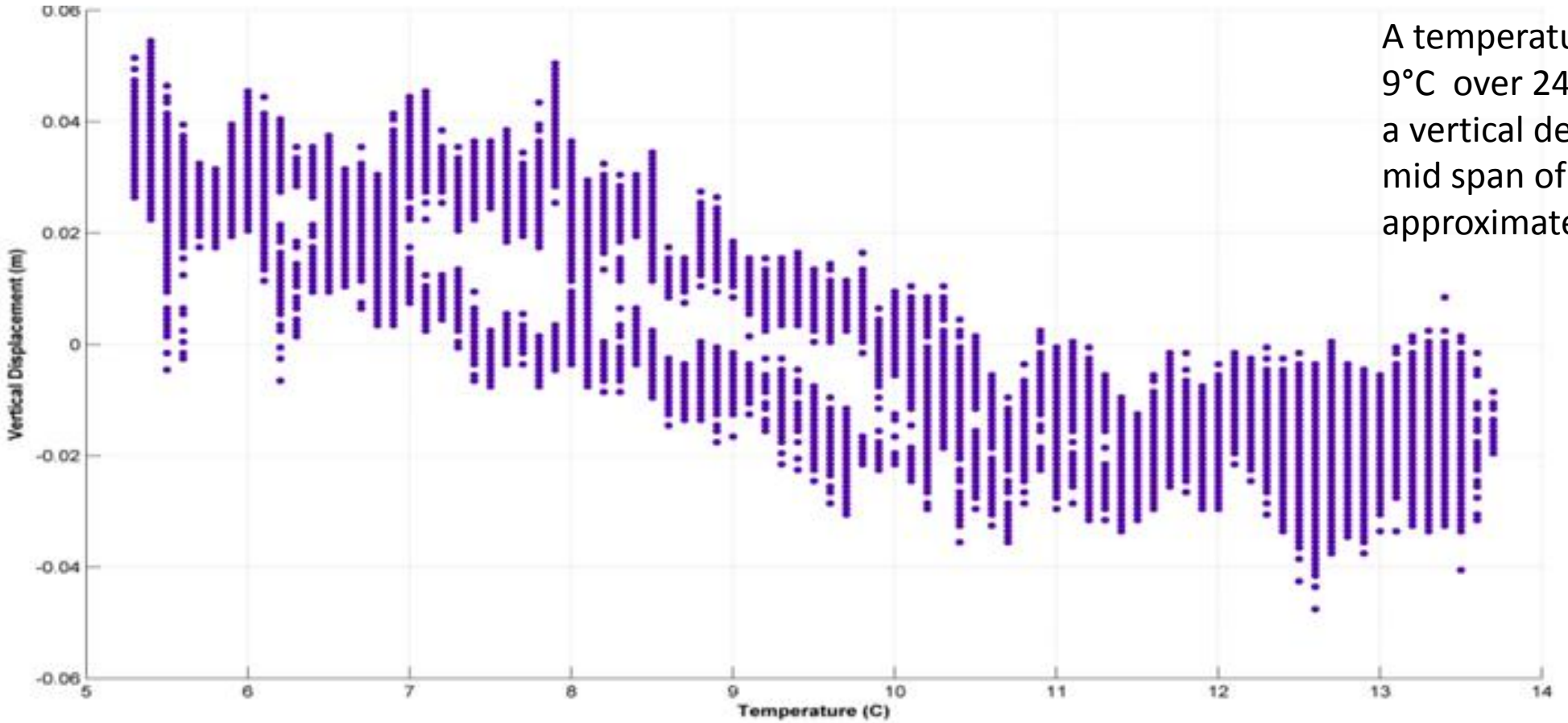
Test with GNSS, measurements at mid-span



Red: Vertical
Yellow: Longitudinal
Blue: Lateral
Green: Coordinate Quality

- Max. displacement approximately 100 mm
- Coordinate quality between 1-10 mm
- Sudden changes can be explained with changes in coordinate quality.
- Design criteria for deflection have been verified

Bridge temperature – vertical displacement correlation

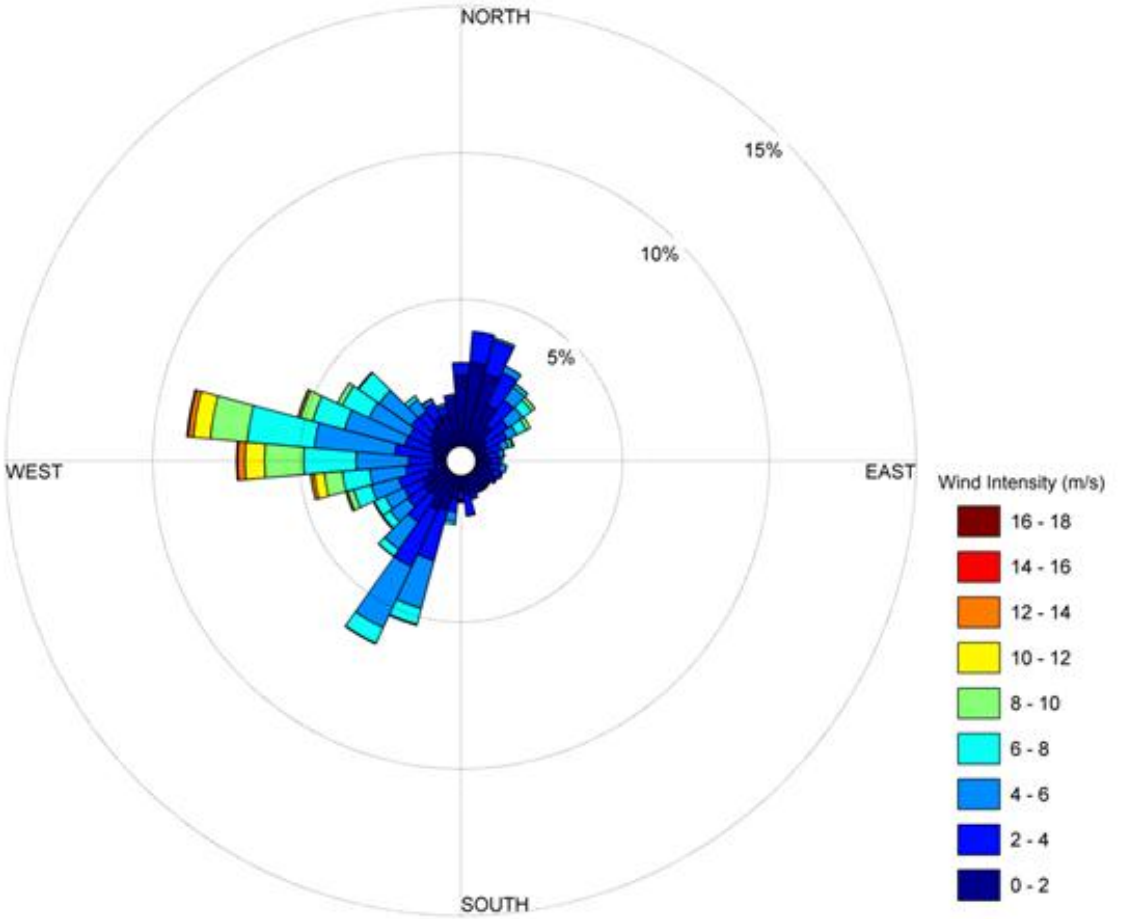


A temperature change of 9°C over 24h resulted in a vertical deflection at mid span of approximately 45 mm.

Present and future work

SHM system work:

- A reference GNSS-antenna on the abutment for more accurate longitudinal measurements.
- A wind sensor at mid-span for more accurate wind data
- More reliable data capturing from the accelerometers
- Better accelerometer resolution
- A database for acquired data.
- Some financial support would be great!



Wind speed and direction, one week

THANK YOU FOR YOUR ATTENTION

If want more information please contact me at:

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