

# Spokane River Rail Bridge – Construction Monitoring

**PARTNER: GEO-INSTRUMENTS**

## How wireless tilt sensors played a key role in monitoring the stability of an existing railway bridge during adjacent construction activity

### Overview

The BNSF Spokane River Bridge project in Washington State, USA involves construction of a new rail bridge adjacent to the existing bridge. GEO-Instruments is monitoring the existing bridge for potential impacts from the construction, which includes vibratory pile driving for a temporary pile-supported work trestle.

GEO-Instruments deployed three automated monitoring systems that separately report displacements, vibration, and tilt measurements to their data visualization and management tool - GeoCloud. The GeoCloud website for this project continuously updates graphs and data for all three systems, sends alerts as needed, and generates weekly reports.

### Monitoring Displacements

Displacements, including settlement, are monitored at 12 measurement points by a single AMTS system. Measurements are reported at 4-hour intervals initially but can be shortened to 1-hour intervals, if necessary. At maximum distances of 500-feet, the system provides measurement accuracy of around  $\pm 1$  mm.

The AMTS is positioned on a free-standing tower about 16 feet high. The tower provides uninterrupted lines of sight to all of the the monitored elements as well as security for the instrument.

L-bar mini prisms are installed at the measurement points using clamps on steel elements and masonry anchors on concrete elements. Reference prisms are installed at stable locations outside the zone of influence.

Photo 1 shows the AMTS system on its gravity-base tower. The tower also supports two solar panels and a gateway for the wireless tiltmeters.



Photo 1

### Key Points:

- BNSF Spokane River Bridge project involves construction of a new rail bridge adjacent to the existing bridge.
- GEO-Instruments developed a comprehensive monitoring program for the existing bridge including AMTS, prisms, vibration monitors, and Senceive's wireless tiltmeters.
- All data, including the data from the tiltmeters, is available on GEO-Instruments' data visualization platform, GeoCloud. Data from the tiltmeters is sent hourly to monitor rotational movement.

## Monitoring Vibration

Vibration levels are measured by automated vibration monitors installed on two abutments, two steel bents, and two concrete piers.

The monitors are placed on the side of the bridge closest to the contractor's activities, with geophones anchored directly onto concrete elements or clamped onto steel elements.

The vibration monitors operate continuously, obtaining 1024 samples per second, but storing only peak values for each 5-minute interval. If alert thresholds are exceeded, the monitors record a 10-second wave form and initiate an immediate upload to the project website that sends out email or text message alerts. Waveform reports allow exceedance events to be further analyzed with FFT frequency domain reports.

Photo 2 shows one of the solar-powered vibration monitors with geophone and also a co-located prism and tiltmeter.

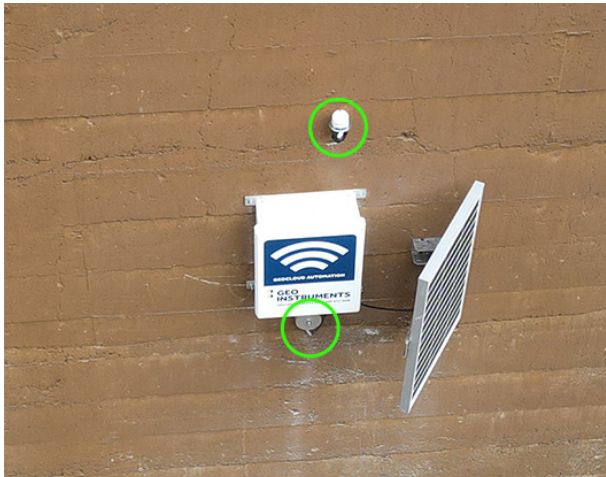


Photo 2

## Monitoring Tilt with Senceive Sensors

Potential rotation is monitored by eight wireless Nano Triaxial Tiltmeters from Senceive, two on each of the two steel bents, one on each of the concrete piers, and one on each of the steel supports founded on the concrete piers. The wireless tiltmeters report measurements hourly and are co-located with the L-Bar prisms.

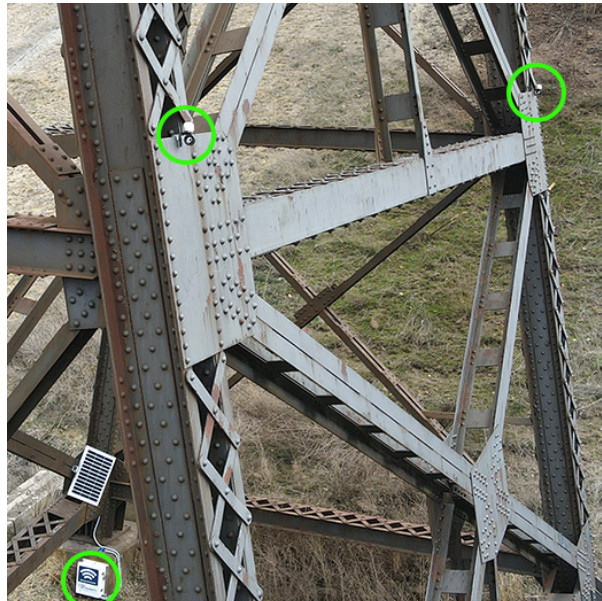


Photo 3

Potential rotation is monitored by eight wireless Nano Triaxial Tiltmeters from Senceive. The tiltmeters report measurements hourly



## Project Website & Data Presentation

The GeoCloud project website automates processing of measurements, standardizes presentation, and provides timely access to data. Plan views, plots and reports are preconfigured to ensure consistent scales, terminology, and sensor selection. Values are updated automatically when new measurements arrive.

Photo 3 shows two tiltmeters (co-located with prisms). A vibration monitor can be seen at the bottom left.

## Baselines and Thresholds

The AMTS system obtained a week of data for baseline measurements. Threshold levels for settlement alerts were set at 0.25 inches. Threshold levels for suspension of work and corrective action were set at 0.5 inches.

The vibration monitors obtained a week of data for baseline measurements of the geophones, which were installed directly onto the structural elements. This allows structural responses to construction activities to be compared to responses to normal rail traffic. Vibration alert thresholds are set according to the type of structure, its age, and its condition.

Tiltmeters also collected a week of data for baseline measurements.