Man-made Seismic Effect Quantification/Vibration Monitoring

With Resensys Wireless Vibration/ Acceleration SenSpot™ Sensors Measurements

Man-made seismic effect or **human induced seismicity** is defined as typical slight earthquakes and tremors that are caused by human activity that change the stresses and strains on the Earth's crust. Most induced seismicity is of a small amount magnitude. The human activities that may cause induced seismicity include quarrying, mining, dam reservoir impoundment, extraction of ground water, production of oil or gas, injection of wastewater or fluids underground, the injection of fluids to enhance oil or gas recovery, geothermal stimulation, or hydraulic fracturing.[1]

Typical applications of man-made seismic effect quantification monitoring include **detecting shift in natural frequencies**, **calculating natural frequencies/ modal analysis** and **monitoring single axis or tri-axial acceleration on structural members.**

In highway bridge structures, vibrations and seismic effects are induced by travelling vehicles. Bridge structures seem fixed and stable in their places. In reality these huge structures do frequently experience light and gradual vibrations that, depending on the vibration frequency, may damage the structure and compromise their stability.

Thus it is important to monitor these tiny vibrations on various members of a bridge to be able to take pro-active measures to forestall any possible damage and destruction of bridge structure and instability of bridge corresponding elements. Resensys' wireless structural health monitoring solutions are designed to efficiently help monitor and precisely quantify human induced seismicity, providing accurate vibration data to structure owners and authorities.

The applicable, measurable and monitorable quantities in man-made seismic effects are vibration (single axis acceleration or tri-axial acceleration; X, Y and Z axis) and ambient temperature.

Resensys'structural health monitoring system uses wireless long term, cost-effective and accurate SenSpot™ sensors to monitor vibration on different structural members of a bridge or other concrete, steel or composite structure that may experience human induced seismicity. The system allows advance warning of potential damage or instability by detecting early signs of structural issues and by collecting quality, reliable steady-state vibration data over time against which these signs can be interpreted. Resensys' wireless design reduces installation cost and time, making it a cost-effective way for authorities to get the data they need. Moreover, the Resensys Wireless Vibration/Acceleration SenSpot™ sensor can be installed very quickly and easily on the intended member without needing field calibration. After installation, SenSpot™ does not need battery replacement or any other maintenance during its entire service life. The ultra-low power usage allows short term and long term use.

[1] ags.aer.ca/activities/induced-seismicity.html

Resensys Wireless Vibration/Acceleration SenSpot™ sensors are small in size and lightweight. Collected data by these gauges is adjustable in sampling interval, sensitivity threshold and transmitting interval. Threshold can also be set adaptive to limit the number of events collected. Furthermore, Resensys SenSpot™ works in extreme low and high temperature (40°C to +65°C or -40°F to +150°F) to monitor single axis or tri-axial acceleration and ambient temperature in concrete, steel and composite materials under wet, humid and extreme weather conditions. The products are corrosion resistant and can withstand salty environments.

A Resensys man-made seismic effect quantification/ vibration monitoring solution comprise the following components:

- SenSpot™ sensors (for vibration): which are attached to a bridge (Required number of sensors per structure, depending on design and monitoring needs).
- SeniMax™: gateway/ data logger which collects SenSpot™ data at the site and sends it to a remote server (one unit can cover as many as 100 SenSpot™ sensors).
- Repeater: may be used to extend the range of the SenSpot™ sensors.
- SenScope™: software for data analysis and visualization.

Vibration SenSpot™ sensor on a abutment for man-made seismic effect quantification/ vibration monitoring

Vibration/ Acceleration SenSpot™ sensor on a abutment for man-made seismic effect quantification/ vibration monitoring

Vibration SenSpot™ sensor on the middle web of a span girder for man-made seismic effect quantification/ vibration monitoring

Vibration SenSpot™ sensor on a pier for man-made seismic effect quantification/ vibration monitoring

Resensys SenSpot™ sensors are easily placed/ installed on critical elements that their vibration can be significant (such as piers, columns, abutments, floorbeams and span girders (web & flange)) as determined by inspection, finite element modeling or authority's/client's suggestion. Since they are wireless, no additional wiring is required, and the sensors are mounted with adhesive or flange mounted depending on the application. The SeniMax™ data acquisition unit is conveniently mounted nearby (within 1.0Km (0.62miles) free space of the SenSpot™ sensors) and a SenScope™ Module is installed on the client's/authority's laptop or PC.

A complete Resensys SHM system includes software and hardware components for (1) the reliable collection of SenSpot™ data, (2) aggregation of the data, (3) the addition of timestamps, (4) communication of encrypted data to a remote server, and finally, (5) an interface for data visualization and detection of structural issues. The graphic below depicts a Resensys SHM system, which can be used for vibration monitoring.

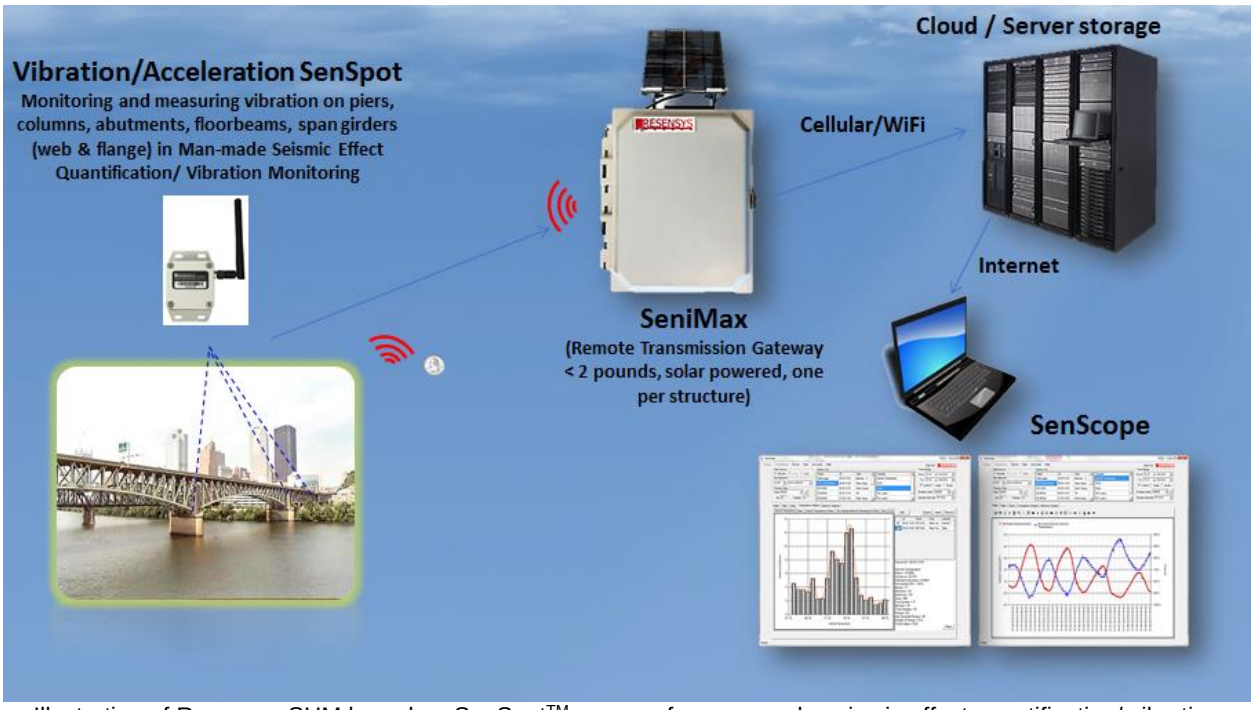
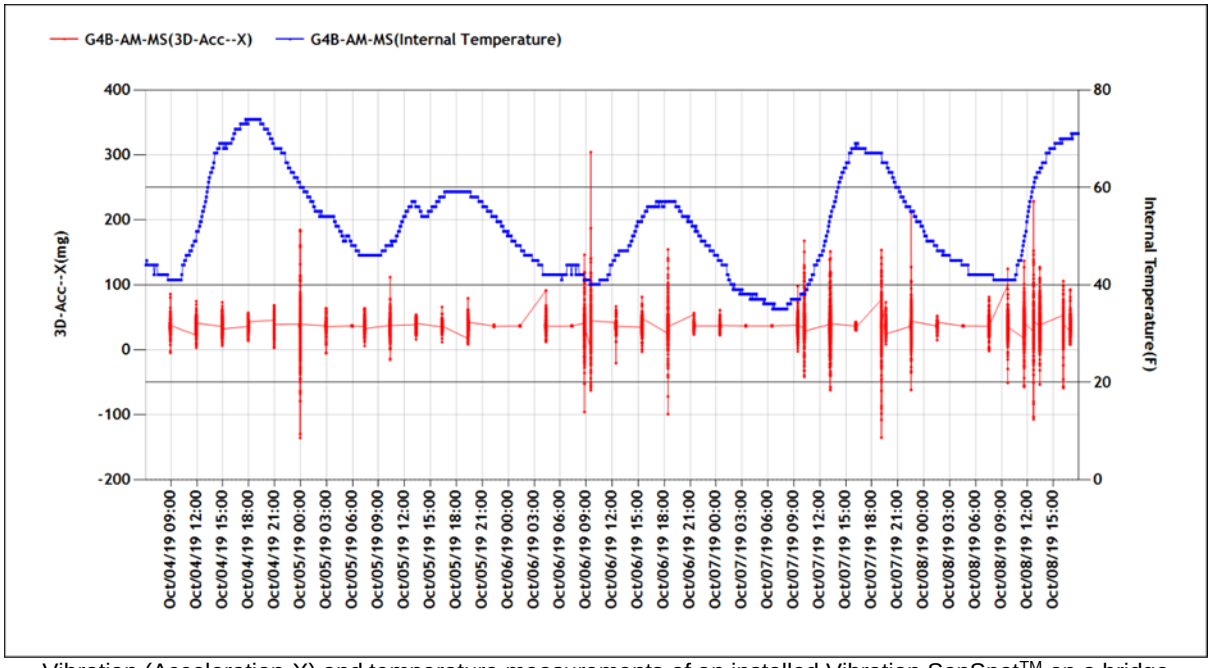
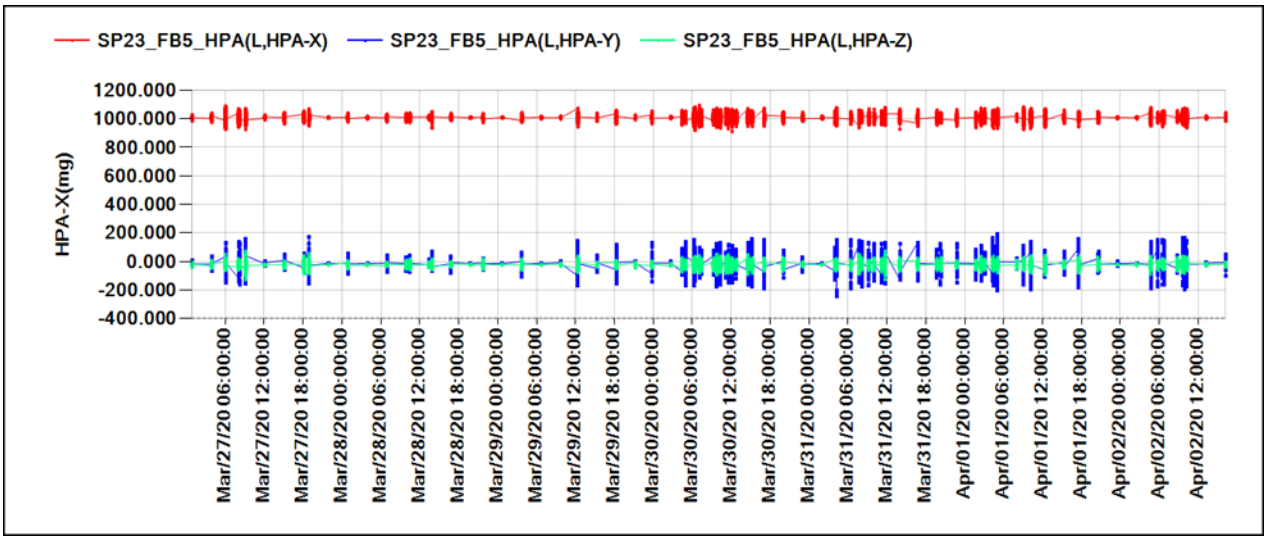


Illustration of Resensys SHM based on SenSpot™ sensors for man-made seismic effect quantification/ vibration monitoring



Vibration (Acceleration-X) and temperature measurements of an installed Vibration SenSpot™ on a bridge



Accelerometer measurements (X, Y and Z) of an installed Vibration/ Acceleration SenSpot™ on a bridge

Technical Specifications:

	Wireless Vibration/Acceleration SenSpot™ sensor
Size (Dimension)	50mm (1.96") x 50mm (1.96") x 34mm (1.34")
Weight	About 120grams (4.2 oz.)
Mounting	- Self-adhesive, no drilling is required (e.g. steel) -Flange-mount, drilling is required (e.g. concrete)
Accuracy (Resolution)	4 ug ("g" is the acceleration of gravity)
Measurement Range	±2g ("g" is the acceleration of gravity)
Operating temperature	-40°C to +65°C (-40 °F to +150°F)
Lifetime	battery life of 10 years (Ultra-low-power)
Installation Time	1-2 minutes
Complementary sensing	temperature, battery voltage, etc.
Communication range	1.0km(0.62mile)free space
Power source	Replaceable lithium ion battery
Wireless communication	no wiring needed for deploying the system- IEEE 802.15.4