Fracture critical monitoring

With Resensys Wireless Strain SenSpot Sensors Measurements

Fracture Critical Member (FCB) is defined as component in tension whose failure is expected to result in the collapse of the bridge/structure or the inability of the bridge/ structure to perform its function.[1] A fracture-critical bridge or other structure has a structural component of which failure could lead to bridge distress and possibly collapse. The failure of a single major tension member or member element is likely to cause a significant portion or the entire bridge to collapse due to a lack of redundancy. Fracture critical designs can leave bridges vulnerable to possible collisions with ships or large trucks.

A bridge/structure can become fracture critical if deterioration over time leads to degradation of materials compared to their original design strengths, or if loading use increases such that designed redundancy is reduced.

It is important that (fracture critical) bridges/ structures and their corresponding members are regularly inspected, with increasing frequency as they age. To help determine when inspections are needed and provide data to inform owner's decisions, fractural critical monitoring solutions, can be used. The applicable, measurable and monitorable quantities in Fracture Critical bridges/structures are strain, tilt, displacement and ambient temperature. Resensys has developed a structural health monitoring system that uses wireless long term, cost-effective and accurate SenSpot sensors to provide advance warning of potential failure by detecting early signs of structural distress and by collecting steady-state data against which these signs can be interpreted. Resensys' wireless design reduces installation cost and time, making it a cost-effective way for owners to get the data they need. The ultra-low power usage allows short term and long term use. The ability to collect quality, reliable data over time provides owners with an established historical data pattern against which they can interpret changes to their fracture critical element.

Typical applications of fracture critical monitoring include steel bridges, long span concrete bridges, bearings, piers, girders, truss members, gusset plates, floor beams, stringers, parking garages, pedestrian walkways, rail road structure and bridges, foundation, power and utility or petrochemical support structures.

By monitoring strain and temperature on different members and structures to determine strain variations caused by temperature change and live traffic, data is provided which can be used for early stage detection of issues related to fatigue or formation of cracks. Resensys structural health monitoring solutions provide SenSpot data, which can also help determine load-bearing capacity of a bridge as well as detecting occasional overstrains caused by vehicles violating a bridge's maximum allowed load.

Resensys SenSpots are able to monitor structural quantities such as tilt, displacement, strain 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 Fracture Critical Monitoring solution comprises a combination of wireless SenSpot sensors (wireless Strain SenSpot sensor, wireless Tilt SenSpot sensor, and wireless Displacement SenSpot

[1] The AASHTO *LRFD Bridge Design Specifications* (LRFD), 6th Edition

sensor) to measure and collect the data required for your situation, a SeniMax Gateway to transmit data away from the site and a SenScope Display user-interface.

Strain SenSpot sensor in girder for fracture critical monitoring

Tilt SenSpot sensor on bearing for bridge fracture critical monitoring

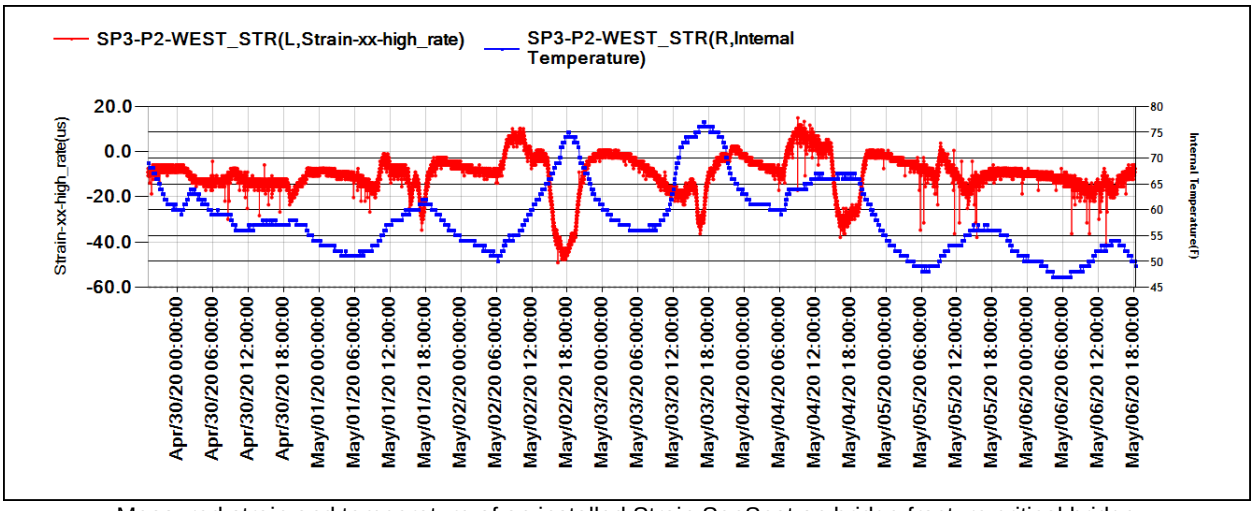
Resensys SenSpot sensors are easily placed/ installed on critical elements as determined by inspection, finite element modeling or authority's/client's suggestion. Since they are wireless, no additional wiring is required, and the sensors are mounted with adhesive or flange mounted depending on the application. A Senimax data acquisition unit is conveniently mounted nearby or conveniently mounted 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. Figure below shows a picture of a practical Resensys SHM system, which can be used for structural monitoring.

The system includes the following components:

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

Illustration of Resensys SHM based on SenSpot sensors for fracture critical monitoring



Measured strain and temperature of an installed Strain SenSpot on bridge fracture critical bridge

Technical Specifications:

	Wireless Strain SenSpot sensor	Wireless Tilt SenSpot sensor	Wireless Displacement SenSpot sensor
Size (Dimension)	76.2mm (3") x 33.4mm (1.3") x10mm (0.4")	-Transmitter Dimension: 79.6mm(3.13")x74.6mm(2.94″) x 52mm(2.05") -AssemblyDimension:120.8mm (4.76") x 96.6mm (3.8")x149.9mm (5.9")	Model 2": 176mm [6.9"], Model 3": 201mm[7.9"], Model 4": 227mm[8.9"], Model 6": 277mm[10.9"]
Weight	147g (5.2 oz.)	180 g (6.3 oz.)	245 g (8.6 oz.)
Mounting	- Self-adhesive, no drilling is required (e.g. steel) -Flange-mount, drilling is required (e.g. concrete)	Flange-mount or adhesive tape	self-adhesive or flange-mount
Accuracy (Resolution)	2μStrain	-Narrow Range HRT: ≤0.0003^0 (5.2μrad) -Regular tilt : 0.1^0	0.1mm (4mil)
Measurement Range	-	-Operating range: • Narrow Range High Resolution Tilt : ± 0.5^0 (with respect to vertical position) • Regular tilt: all directions -Linear range: • Narrow Range HRT: ±1^0 • Mid-Range HRT: ±10^0 -Repeatability: • Narrow Range HRT: ≤0.001^0 (17.5μrad) • Regular Tilt:1^0 -Time constant: ≤1sec(High resolution tilt)	25mm (1"), 50mm (2"), 75mm (3"), 100mm (4"), 150mm (6"), 300mm (12")
Operating temperature	-40°Cto +65°C (-40 °F to +150°F)	-40°C to +65°C(-40°Fto +150°F)	-40°C to+65°C(-40°F to +150°F)
Lifetime	minimum expected life without battery replacement is 3 years (Ultra-low-power)	battery life of 10 years (Ultra-low-power)	battery life of 10 years (Ultra-low-power)
Installation Time	1-2 minutes	1-2 minutes	1-2 minutes
Complementary sensing	temperature, battery voltage, etc.	temperature, battery voltage, etc.	temperature, battery voltage, etc.
Communication range	1.0km(0.62mile)free space	1.0km(0.62mile)free space	1.0km(0.62mile)free space
Power source	Replaceable lithium-ion battery	Replaceable lithium ion battery	Replaceable lithium-ion battery
Wireless communication	no wiring needed for deploying the system-IEEE 802.15.4	no wiring is required for data collection- IEEE 802.15.4	no wiring needed for deploying the system-IEEE 802.15.4