

## Bridge Load Rating with SenSpot™ as test tool (using truck tests) - Obtaining Strain Responses with Resensys Wireless Strain SenSpot™ Sensors

The Load Rating is a measure of bridge live load capacity. Load Rating is commonly defined in two forms:

- **Inventory Rating**, as defined by the current AASHTO Manual for Bridge Evaluation,<sup>1</sup> is that load, including loads in multiple lanes that can safely utilize the bridge for an indefinite period of time.
- **Operating Rating**, defined by the same manual, is the maximum permissible live load that can be placed on the bridge. This load rating also includes the same load in multiple lanes. Allowing unlimited usage at the Operating Rating level will reduce the life of the bridge.

Having accurate and up to date Inventory and Operating Ratings are important to meet inspection and reporting requirements and ensuring that the correct bridge postings are achieved. They also allow infrastructure owners to make informed asset management decisions with regard to overall traffic pattern management, asset rehabilitation/ reinforcement to meet current or changing demands over time, and ensure that bridges can be safely operated and utilized.

DOTs, Authorities and other asset owners spend significant resources in validating and refining their load rating models and ensuring compliance with rule changes that could require re-rating of bridges based on updated truck requirements.

The applicable, measurable and monitorable quantity in bridge load rating is strain.

The Resensys Wireless Strain SenSpot™ sensors measurements responses are well-suited for bridge structure load rating due to their quick installation, and accurate, reliable, repeatable results, with no need for field calibration. The monitoring system can be installed during the routine NBIS (National Bridge Inspections Standards Regulation) safety inspection of a bridge. 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 (bridge load rating) and long-term use (bridge structure health monitoring).

Resensys SenSpot™ sensors are able to monitor these structural quantities in concrete, steel and composite materials under wet, humid and extreme weather conditions. The product is corrosion resistant and can withstand salty environments.

A Resensys Bridge Load Rating solution comprises [Wireless Strain SenSpot™ sensors](#) on the location of girders, gusset plates, bearings and truss members, a [SeniMax™ Gateway](#) to transmit data away from the site and the [SenScope™](#) display user-interface.

---

<sup>1</sup> Manual for Bridge Evaluation, AASHTO, 2011.



Resensys Wireless Strain SenSpot™ sensor installed on the bridge for bridge load rating

Resensys SenSpot™ sensors are easily placed/ installed on critical elements as determined by inspection, finite element modeling, load rating model 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 (for strain): which are attached to a bridge (Required number 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 SenSpot™ sensors).
- Repeater: may be used to extend the range of the SenSpot™ sensors.
- SenScope™ software for data analysis and visualization

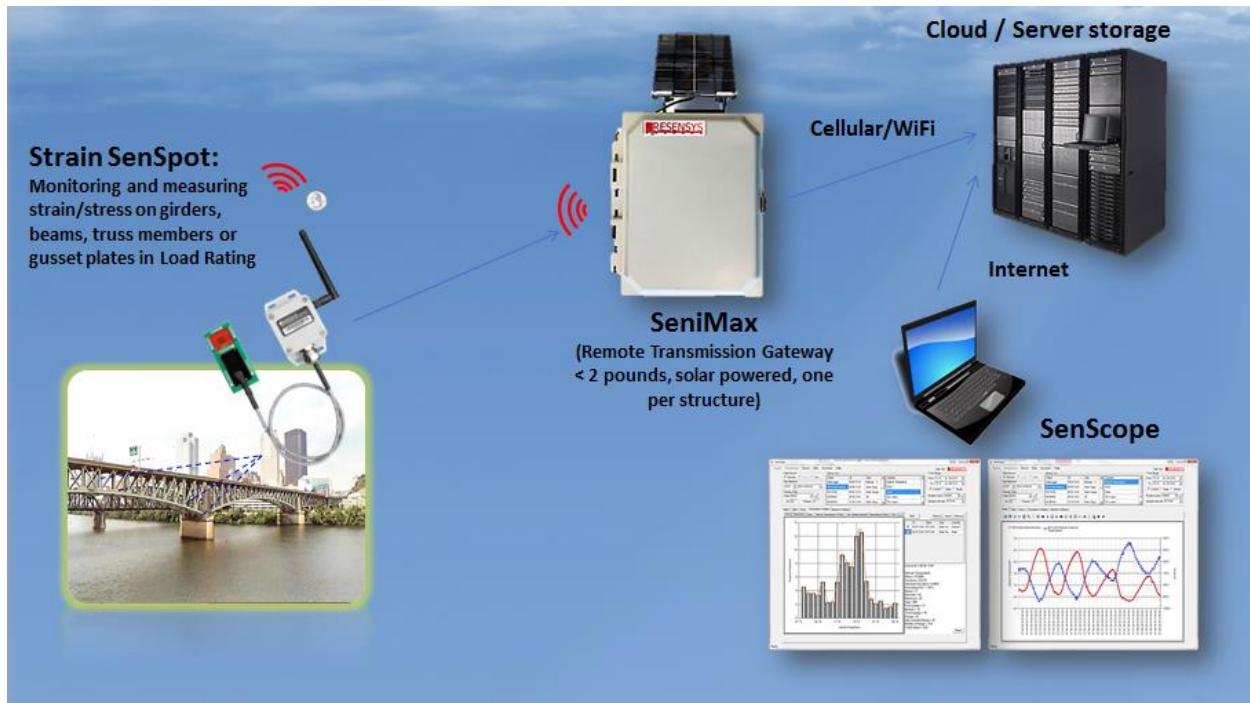


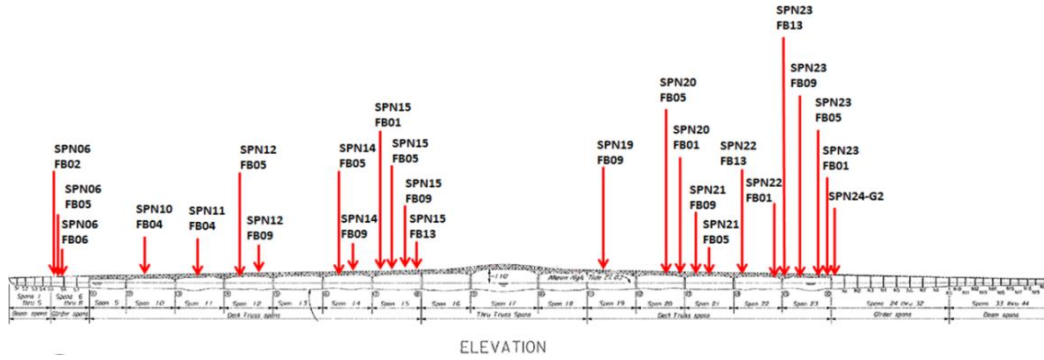
Illustration of Resensys SHM based on SenSpot™ sensors for bridge load rating

**Load Testing:** For load testing, one or two trucks (depending on bridge) with known weight are slowly driven over the bridge in different lanes and directions to maximize the loading on the gauged floor beams and girders. A comparison of the load effect of the moving truck on each of the locations where a strain SenSpot™ sensor is installed is provided to the authority/owner. The measured strains produced by trucks are then compared to the calculated stresses in these members generated from AASHTOWare's BrR load rating model. This information can then be used to see if the load rating is accurately modeling the performance of the members.

Frequently, load testing activities allow short-term load testing data to be gathered. However, Resensys' system works continuously from the time of installation, and alert systems monitor any change in the strain on girders, bearings, gusset plates and truss members of the bridge for as long as the sensors are left in place. The continuous data from these sensors can be generated as a monthly (or custom) report for the district showing the peak strains that are produced by standard traffic utilizing this bridge. Due to the ultra-low power usage of Resensys' products, this data and reporting can continue virtually maintenance-free for up to 10 years allowing future analysis and testing without the need for additional set-up.

To conclude, a breakthrough method steps for fast and accurate bridge load rating are:

- 1- Attach adhesive mount wireless strain SenSpots™ to critical members (e.g., beams, girders, truss members, gussets);
- 2- Drive truck of known weight (steer axle, drive 'tandem axle and gross weight) over the bridge;
- 3- Calculate load carrying capacity using the responses of the members.



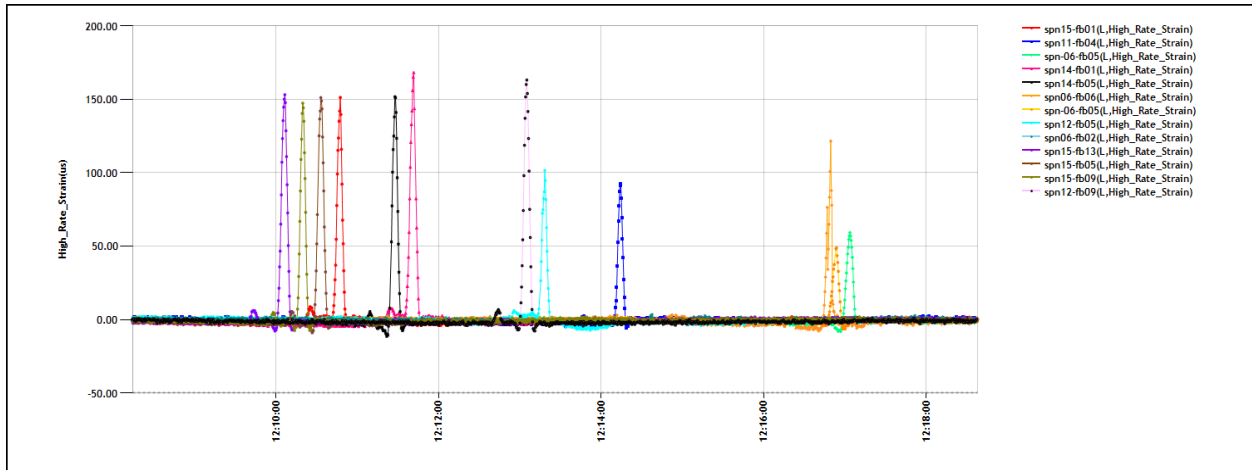
SenSpot™ as test tool for bridge load rating by using truck(s) tests

**Technical Note:** For the purpose of calculating and presenting results, the following method has been used.

**Baseline reading:** is calculated as the average of the ten strain readings of a strain gauge right before the truck passes over the bridge.

**Strain increase:** for each device, strain increase is calculated as the difference between the maximum and the baseline.

Finally, small strain variations of about  $\pm 1$  microstrain from one test to another are result of sensor resolution and the effect of small random vibrations in the structure at the time that the truck was passing over.



Strain peaks on various members caused by test truck

**Technical Specifications:**

	<b>Wireless Strain SenSpot™ sensor</b>
<b>Size (Dimension)</b>	76.2mm (3") x 33.4mm (1.3") x10mm (0.4")
<b>Weight</b>	147g (5.2 oz.)
<b>Mounting</b>	- Self-adhesive, no drilling is required (e.g. steel)  -Flange-mount, drilling is required (e.g. concrete)
<b>Accuracy (Resolution)</b>	2 $\mu$ Strain
<b>Measurement Range</b>	-
<b>Operating temperature</b>	-40°Cto +65°C (-40 °F to +150°F)
<b>Lifetime</b>	Minimum expected life without battery replacement is 3 years (Ultra-low-power)
<b>Installation Time</b>	1-2 minutes
<b>Complementary sensing</b>	Temperature, battery voltage
<b>Communication range</b>	1.0km(0.62mile)free space
<b>Power source</b>	Replaceable lithium ion battery
<b>Wireless communication</b>	No wiring needed for deploying the system- IEEE 802.15.4