ELECTROMAGNETIC INSPECTION OF SUSPENDER CABLES IN SUSPENSION BRIDGES

Driving over the suspension bridge can be a pleasing experience, however, danger lurks in many unexpected places: every other day a bridge in the USA fails, sags or buckles, resulting in needless death and injuries. Most critical components for the stability of the suspension bridge are vertical suspender cables. If only one of them breaks, the added load to the other cables could cause them to fail. The cables, which hold up a bridge, are constantly exposed to load, vibration and weather conditions, so deterioration is inevitable.

The innovation consists in using the electromagnetic principle to test the entire metal cross-section of the suspender cable, allowing for detection of external and internal damage such as broken wires, corrosion, cracks and wear. It can replace and enhance the visual test, used to date. While the wire rope inspection method known as "magnetic flux leakage" has been known and used before, the bridge application required development and fabrication of special test instrumentation plus designing the procedure to physically move the test instrument along the stationary rope.

The principle of the magnetic flux leakage (MFL) test is based on detection of magnetic field distortion around the damage. It is illustrated in Figure 1. The rope moves through the test sensor where it is magnetized. If there is a continuity of metallic cross section, the entire magnetic flux is enclosed within the rope. Any sharp defect like a broken wire will distort the magnetic flux to the extent that its small portion will protrude onto the rope outer surface. This leaking magnetic field is then detected by the induction coil. While the above arrangement is successful in detecting sharp defects, the semiconductor Hall effect sensor is used for finding gradual loss of metal caused by wear and corrosion. This is recorded on additional data channel and it can be calibrated as direct measurement of rope cross section.

The State of Massachusetts became the first customer for suspender rope inspection when Interstate 95 bridge over Merrimack River – Whittier Bridge was successfully tested in December 1999. The bridge contains 54 vertical cables of two different diameters: 1-7/8" and 2-3/8" and length varying from 16 to 34 ft. One part of the innovation was to prepare the instrumentation in two parts: 1) the test sensor which contained the Neodymium permanent magnet and both induction coils and Hall-effect sensors. The entire test sensor designed for ropes up to 3 inches diameter weighted 75 lbs and was built in two pieces, hinged together, to be opened and easily installed on tested rope. 2) Four-channel strip chart recorder.

The second aspect of the innovation was the development of a field inspection procedure. The inspection for each pair of cables was initiated by installing the return block at the top of rope attachment and threading the nylon rope through the block. The test sensor was then wrapped around each cable base and pulled up the suspender cable by means of a nylon rope and electric winch. Once the sensor reached the top position, it was released at a constant speed down the cable while the data was recorded. The test was quick and easily accomplished: it took six hours to inspect 18 cables with the crew of two with minimal traffic disruption. On many bridges the inspection can be even carried out from the sidewalk.

The Whittier Bridge inspection demonstrated the usefulness of the new technique. Some rope damage was found including internal broken wires invisible to the naked eye. In addition, internal gradual corrosion was identified especially in the areas close to top and bottom attachments. Further, the test was able to quantify the percentage loss of metallic cross section of the cable. The calibration showed that external metal loss of 0.2% and internal loss of 0.5 % could be detected on a rope of this size.

The innovation can be of great use on every suspension bridge to determine the condition of suspender cables and their suitability for continuous service. This technique if used on a periodic basis can establish the growth of cable deterioration and forecast the time for replacement or repair.

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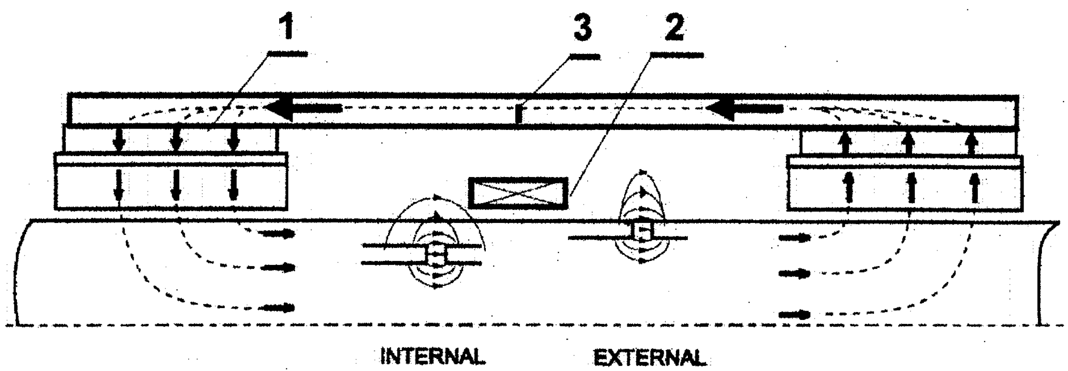

Figure 1. The principle of magnetic flux leakage inspection of wire rope
1. Magnetic Circuit
2. Induction Coil – for detection of sharp defects
3. Hall-Effect Sensor – for detection of gradual defects

Figure 2. Test Instrument Installed on Suspender Rope

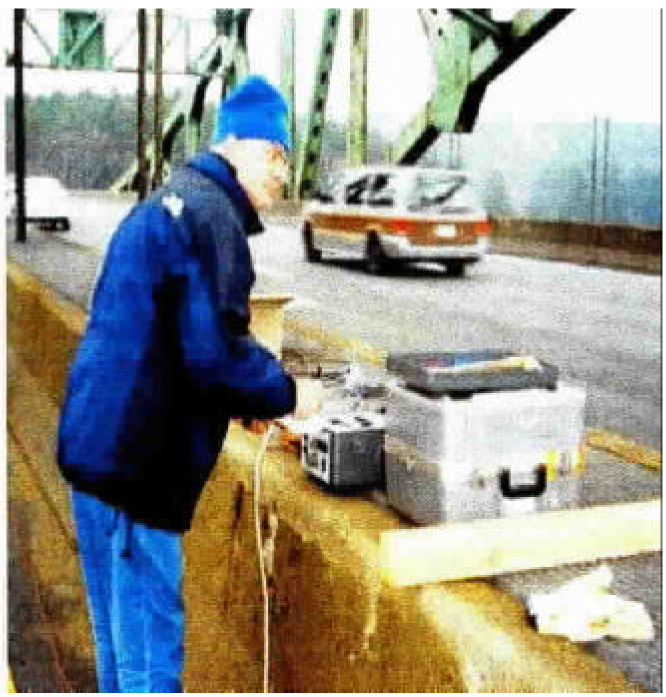

Figure 3. Recording Test Data