

Evaluation and Health Monitoring of the Veterans' Glass City Skyway Stay Cables

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Stay cables are the most critical and vulnerable components of cable-stayed structures. While corrosion is typically the primary driver of deterioration of internal steel strands, other risks to strands include section loss, wire breakage, and moisture infiltration.

Opened to traffic in 2007, the Interstate 280 Veterans' Glass City Skyway (VGCS) in Toledo, Ohio, employs a special stay-cable design to mitigate these risks. However, the unique design features present challenges for standard nondestructive evaluation (NDE) strategies. This article reports on a study to identify practical NDE methods to monitor these stay cables and establish a long-term assessment plan.^{1,2}

Unique Design Features and Challenges

The VGCS stay-cable system incorporates several layers of protection that influence inspection protocols and dictate the selection of NDE technologies. These protection layers include the following:

- Epoxy-coated strands with interstices filled with epoxy: This strand type provides a high level of corrosion resistance by blocking moisture travel into and within the strand itself (Fig. 1). However, the coating is vulnerable to “nicking” (abrasive damage) during installation or through interstrand contact over the bridge’s service life. Such localized damage can lead to coating delamination, potentially exposing bare steel to corrosive elements.
- Large-diameter stainless steel sheathing: The stay cables encase between 82 to 156 strands in a 0.25-in.-thick, 18-in.-diameter stainless steel skin that serves as the primary external barrier. The sheathing provides

superior protection against the environment; however, due to the significant diameter of the sheathing and the resulting standoff distance, many traditional electromagnetic NDE methods designed for smaller, more compact cables are technically inadequate or do not provide sufficiently accurate data.

- UngROUTED configuration and cheese plates: Instead of traditional grouted stay cables, the VGCS has an ungrouted design using “cheese plates” (Fig. 2) to separate individual strands. This configuration is advantageous because it allows for the extraction and replacement of individual strands. However, while laboratory testing of an extracted strand provides definitive data, removing a strand is a destructive and logistically intensive process reserved for high-concern scenarios where NDE methods have already indicated significant section loss.

A Risk-Based Nondestructive Evaluation Strategy

Deterioration in cable-stayed bridges typically initiates at or near the anchorage zones, where moisture tends to collect and stresses are concentrated, rather than along the midlengths of the stay cables. Consequently, investigators for the study described herein implemented a tiered, risk-based approach: evaluating high-risk, accessible areas first, then deploying advanced methods for the midlengths of the stay cables if evidence of significant deterioration was detected.

Advanced Borescope Visual Inspection

Visual inspection remains a high-reliability method for internal assessment when access is available. The research team used existing drain holes

in the sheathing at the lower ends of the stay cables as access ports for visual inspection (Fig. 3).

- Methodology: The team deployed high-definition dual-camera borescopes with four-way articulation to navigate the internal stay-cable environment. This method allowed for a 360-degree view of the strands and the inner surface of the sheathing.
- Findings: Across 14 inspected stay cables, more than 250 photographs

Figure 1. Cross section of a seven-wire stay-cable strand featuring epoxy coating and filled interstices designed to prevent moisture migration and corrosion. All Photos and Figures: Dr. Serhan Guner.



Figure 2. The “cheese plate” assembly maintains the required separation of the ungrouted, noncompacted strands.





Figure 3. Dual-camera borescopes with four-way articulation are used for internal visual inspection through existing stay-cable drain holes.

confirmed the strands were in excellent condition (Fig. 4). The presence of fine dust rather than rust residue or mineral deposits indicated dry internal conditions. Furthermore, the specialized grease at the lower ends appeared stable and showed no signs of water emulsification or contamination.

Environmental Microclimate Monitoring

Corrosion is an electrochemical process that requires moisture and oxygen. By monitoring the microclimate inside the stay cables, engineers can predict the susceptibility of strands to corrosion.

- **Sensor deployment:** For this investigation, probe-based sensors were installed through drain holes (Fig. 5) and coupled to external data loggers attached to the bridge's concrete pylons and shielded from

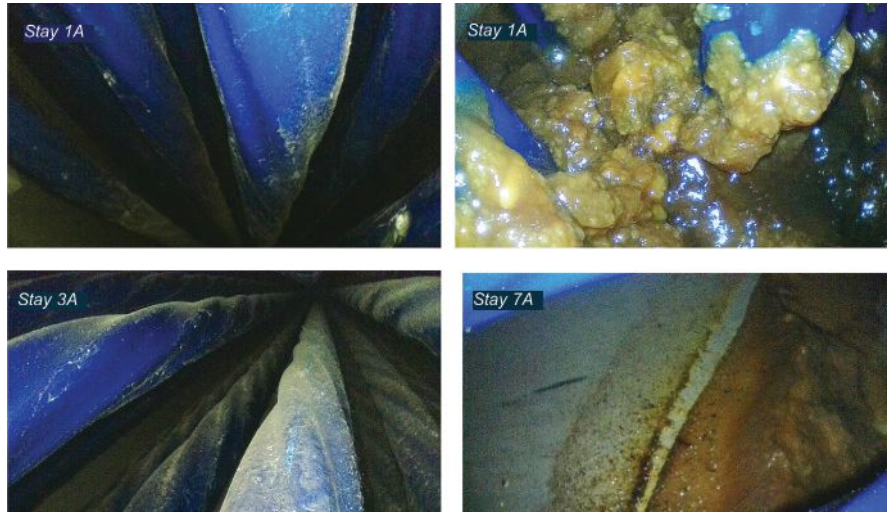


Figure 4. Representative borescope images show the internal condition of the strands. The presence of dust and lack of moisture indicate a dry, healthy internal environment. The upper-right image shows the grease used at the lower ends as a corrosion protection method during the original bridge construction.

solar radiation to capture ambient conditions.

- **Dew point analysis:** The study prioritized dew point—an absolute measure of moisture—rather than relative humidity, which varies with temperature. Data (Fig. 6) indicated that while internal conditions were slightly more humid than ambient levels, there was no evidence of excessive moisture accumulation or sweating (condensation) on the internal stainless steel surfaces.

Global Health Assessment via Laser Vibrometry

Consistency in stay-cable tension is a primary indicator of both stay-cable health and overall superstructure integrity. However, in ungrouted systems, the sheathing and strands may not vibrate as a unified mass



Figure 5. An internal humidity and temperature probe has been installed at the lower stay-cable termination through an existing drain hole to monitor the internal microclimate.

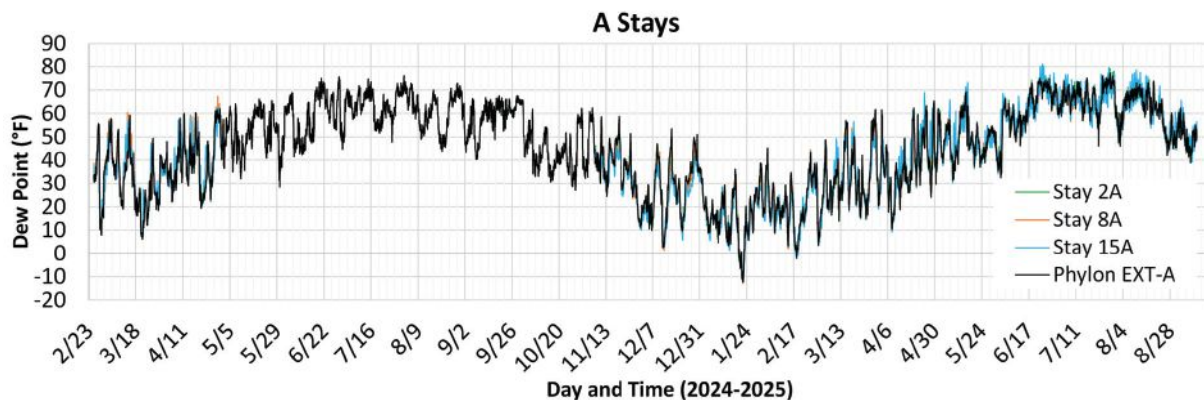


Figure 6. Comparison of internal and external dew point data used as an absolute measure to assess moisture levels and corrosion susceptibility inside the A stay cables, which are located on the north side of the structure.



Figure 7. A laser vibrometer is used to collect data from the Veterans' Glass City Skyway deck during a coordinated lane closure to eliminate traffic-induced vibration noise.

at the lower ends, and that makes traditional accelerometers attached to the sheathing unreliable. Therefore, the team employed laser vibrometry to obtain measurements from the middle third of the stay cables, effectively bypassing the nonunified vibrations present at the lower ends. Laser vibrometry uses a laser to measure the natural frequency (vibration) of a cable; a simple equation is then used to calculate the force in the cable.

- Field testing: To test the laser vibrometry setup, a pilot study was performed from an adjacent bridge that was temporarily closed to traffic. However, to the surprise of the researchers, the measured frequencies corresponded well with the baseline (liftoff) values. During the VGCS evaluation, the Ohio Department of Transportation provided lane closures to eliminate high-pressure shockwaves and deck vibrations associated with heavy truck traffic (Fig. 7).
- Results: The temperature-adjusted stay-cable forces showed a deviation of less than 10% from the original liftoff forces recorded during construction. This finding is well within the expected margin for a healthy structure, indicating that

no significant section loss or strand breakage had occurred.

Conclusion and Recommendations

Based on the integrated NDE findings, no credible concerns were detected regarding the health of the VGCS stay cables. The multilayered protection system of epoxy coating, internal grease, and stainless steel sheathing appears to be performing as designed. To maintain this status, the following long-term monitoring plan for the stay cables is recommended:

- Routine NDE integration: Formalize borescope use and monitoring of moisture within the sheathing as part of the bridge's regular inspection program.
- Cyclic tension testing: Establish a four-year measurement cycle using laser vibrometry to monitor global force distribution.
- Conditional advanced testing: If localized deterioration is detected, deploy advanced methods such as magnetic flux leakage or electrochemical impedance spectroscopy for the free lengths.

By adopting repeatable NDE protocols, bridge owners can move toward a more

predictive health-assessment model, ensuring that structures such as VGCS meet their service-life goals through informed, incremental monitoring.

References

1. Guner, S. 2025. *Veterans' Glass City Skyway Bridge Main Cable Evaluation*. Final report. Columbus: Ohio Department of Transportation. <https://www.utoledo.edu/engineering/faculty/serhan-guner/docs/R4-VGCS-FinalReport-2025.pdf>.
1. Guner, S. 2025. *Ohio Department of Transportation Research Project Fact Sheet: Veterans' Glass City Skyway Bridge Main Cable Evaluation*. Columbus: Ohio Department of Transportation. <https://www.utoledo.edu/engineering/faculty/serhan-guner/docs/R4-VGCS-factsheet-2025.pdf>.

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