StructureIQ

Pedestrian Bridge Structural Monitoring

APPLICATION NOTE

Reduce Risk of Pedestrian Bidge Failures

Executive Summary

Pedestrian bridges are highly sensitive to dynamic loads from crowds, and are susceptible to "invisible" degradation like corrosion inside suspension cables, or micro-fractures in truss members , or settling in the foundation. Recent catastrophic failures have tragically highlighted the inadequacy of relying solely on periodic visual inspections to ensure public safety.

StructureIQ offers a proactive solution: a high-resolution, wireless Structural Health Monitoring (SHM) system that provides a real-time and continuous, data-driven view of a bridge's integrity. By detecting early warning signs of degradation, load anomalies, and seismic stress, StructureIQ empowers operators to move from reactive repairs to predictive maintenance, preventing failures before they occur.

The Challenge: Silent Threats to Pedestrian Infrastructure

Structural failures often result from cumulative, hidden issues rather than sudden events, triggered by critical load conditions. Key points include:

- **Run-to-Failure Trap:** Traditional maintenance relies on scheduled visual inspections, which fail to detect internal and hidden damage.
- **Corrosion & Aging:** Elements accelerate oxidation, making internal corrosion in critical components hard to detect until damage is severe.
- **Dynamic & Seismic Loading:** Crowd Loading Seismic Activity: Pedestrian traffic generates forces that can lead to resonance and fatigue. And minor tremors can cause micro-fractures over time.
- **Design Flaws and Construction Defects:** Structural failures resulting from Under-designed connections or unexpected load paths and stress concentrations.

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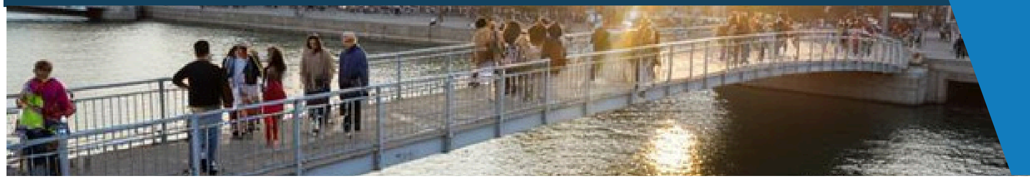


StructureIQ Solution offers continuous, data-driven risk assessment

- **Structural Instability**: Monitors vibration and tilt to detect issues from weakened joints or seismic damage.
- **Seismic Response:** High-frequency sampling during events such as high winds, heavy rain, unexpected crowds, or earthquakes to assess structural impact.

Real-world examples showcase the risks of undetected degradation and the benefits of wireless monitoring.

The Florida International University Pedestrian Bridge (USA) — Design Flaws and Misinterpreted Warning Signs

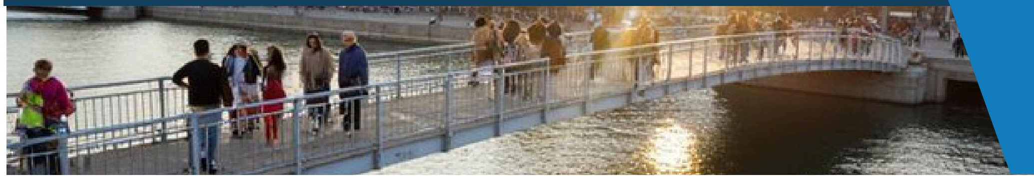
- Incident: A 950-ton concrete span of a pedestrian bridge under construction collapsed onto a busy highway, resulting in 6 fatalities and 10 injuries.
- Root Cause: The NTSB determined the probable cause was load capacity calculation errors made by the design engineers, regarding shear forces at a critical concrete connection node.
- Relevance: Real-time accelerometer data could have detected the abnormal settling vs normal construction settling.

The Cuernavaca Footbridge (Mexico) — **Structural Instability**

- Incident: Collapse during an inauguration ceremony due to structural separation.
- Root Cause: Instability under dynamic load (walking officials) that was not evident in static checks.
- Relevance: Real-time accelerometer data could have detected the abnormal sway and resonance.

Mahomet Bridge (USA) - **Damage Detected by Wireless SHM sensors**

- Context: Historic steel truss bridge (built in 1912) for pedestrians, equipped with a wireless sensor network.
- Detection: Sensors identified damage in specific truss elements, marking them as hazard zones.
- Verification: Engineers confirmed "significant corrosion damage" where sensors indicated.
- Key Takeaway: Wireless SHM effectively detects "invisible" degradation missed by visual inspections.



APPLICATION NOTE: Reduce Risk of Pedestrian Bidge Failures

Implementation Strategy: Comprehensive High-Resolution Array

For critical infrastructure or aging assets that require precise damage localization, StructureIQ recommends a high sensor density. This approach mirrors the high-fidelity data collection methods validated in the Mahomet Bridge case study, ensuring no critical element goes unmonitored.

Suspension Footbridge

StructureIQ High-Resolution Deployment Schematic (Suspension Bridge) in Figure 2 below, illustrates a high-density deployment on a suspension bridge. Wireless strain sensors are attached to each vertical suspender cable to detect localized impact of corrosion on load transfer. A tri-axial accelerometer array across the span monitors for torsional and vertical instability.

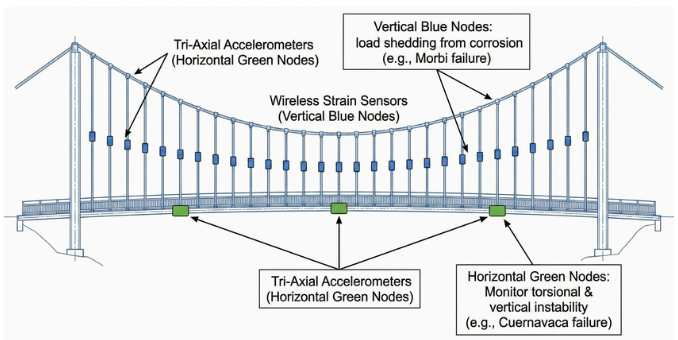


Figure 2: StructureIQ High-Resolution Deployment Schematic

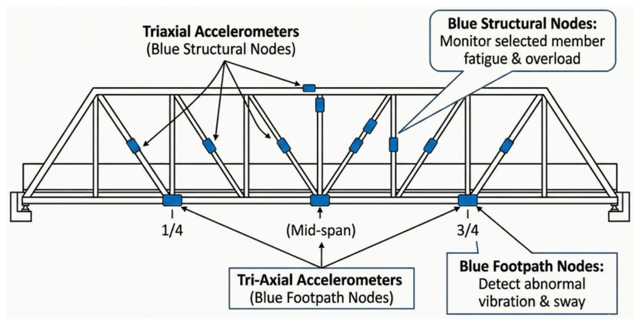


Figure 3: StructureIQ Truss Bridge Sparse Sensor Deployment

Truss Footbridge

StructureIQ Truss Bridge High-Resolution Deployment in Figure 3 above, illustrates a high-density deployment on a truss bridge, similar to the Mahomet example. Wireless accelerometers and strain sensors are placed on all critical diagonal and vertical structural members to monitor for fatigue and overload. Accelerometers on the footpath detect abnormal vibration modes.

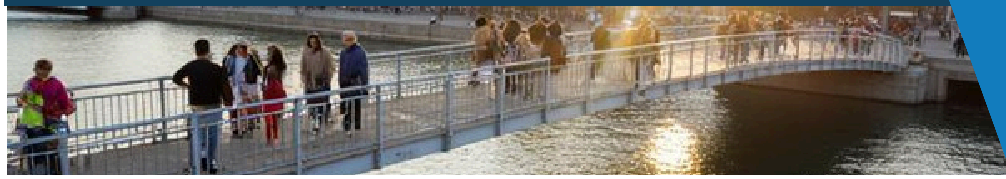
The StructureIQ SaaS Platform

StructureIQ offers secure transmission of high-resolution sensor data to a cloud-based dashboard, converting raw data into actionable intelligence without the need for complex IT infrastructure. Key features include:

High -resolution Sensor

- **Zero-Touch Cellular Connectivity:** Sensors with low-power cellular connectivity (LTE-M/NB-IoT) for easy deployment in remote areas.
- **End-to-End Security:** Encrypted data transmission over cellular networks and secure, SOC 2 compliant cloud hosting.
- **Actionable Dashboard:** Centralized view of bridge health with:
  - Real-Time Visualization of loads and vibrations.
  - Automated Alerts for safety threshold breaches.

SaaS Dashboards



Benefits & ROI: The Value of High-Fidelity Data

Moving to a high-resolution sensor array transforms the SHM system from a simple alarm into a comprehensive asset management tool.

Precision Maintenance vs. Guesswork: A sparsely instrumented bridge might indicate "something is wrong," but a fully instrumented bridge tells engineers exactly what is wrong and where. As proven in the Mahomet study, this data allows maintenance crews to be directed to specific corroded joints, eliminating costly, time-consuming broad inspections.

Liability Shield & Due Diligence: In the event of an incident, a continuous, granular data stream provides an immutable digital audit trail.

Asset Life Extension: Many pedestrian bridges are historic assets. Continuous monitoring allows cities to safely extend the usable life of these aging structures by managing degradation in real-time.

Conclusion

Infrastructure—both newly built and long-standing—is under increasing pressure worldwide. As the Morbi and Cuernavaca tragedies demonstrated, relying solely on periodic visual inspections, even for newly built structures, leaves critical risks undetected. StructureIQ bridges these realities across the full infrastructure lifecycle. By deploying high-resolution wireless sensor networks from the earliest stages of construction through decades of operation, StructureIQ gives a “voice” to both new and aging structures. This continuous stream of objective data enables owners and operators to verify design assumptions, detect emerging risks early, and ensure that pedestrian bridges remain safe, functional, and resilient for the communities that depend on them.

References

References

1. Associated Press (AP). (2022, June 7). Cuernavaca bridge collapse reporting.
2. https://en.wikipedia.org/wiki/Florida_International_University_pedestrian_bridge_collapse
3. Jang, S., et al. (2010). "Structural Health Monitoring of a Cable-stayed Bridge using Smart Sensor Technology: Deployment and Evaluation." Journal of Smart Structures and Systems, 6(5): 439-460.
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