StructureIQ

Commercial Building Structural Monitoring

APPLICATION NOTE

Reduce Risk of Structural Failures with Auotomated SHM

Executive Summary
High-rise buildings present unique structural complexities that differ from low-rise construction. These structures are sensitive to lateral environmental stressors, such as extreme winds, vortex shedding, and seismic activity, and experience dynamic swaying and foundation settlement over time. Critical load-bearing components such as outrigger systems, core walls, and hidden steel connections are often difficult or expensive to access for evaluation. Consequently, "silent" degradation, such as concrete micro-cracking, rebar corrosion, or weld fatigue, is easily missed until damage is severe.

StructureIQ offers a proactive solution: a scalable, wireless Structural Health Monitoring (SHM) system providing continuous, data-driven insights into the building's structural integrity. By detecting anomalous changes in vibration and foundation tilt in real time, StructureIQ enables building owners and facility managers to shift from reactive repairs to predictive maintenance—ensuring occupant safety, protecting assets, and extending the structure's lifespan.

The Challenge: Silent Threats to Vertical Infrastructure

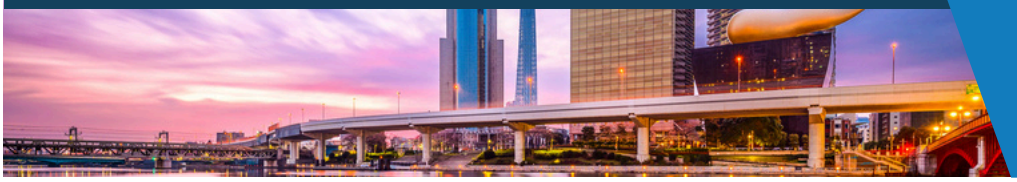
Key challenges:
Inaccessibility and the "Run-to-Failure" Trap Inspecting building' exteriors and cores is costly. Traditional inspections miss hidden damages, letting issues develop unnoticed until safety is compromised.

Design and Construction Flaws: Newly built structures can fail when the as-built varies from the design, or if there is a faulty design.

Environmental Loading & Settlement:

- **Lateral Wind & Seismic Forces:** Buildings sway significantly from winds and vortex shedding. Structural elements weaken due to corrosion and seismic activity. Seismic activity induces damaging inter-story drift that weakens connections over time.
- **Differential Foundation Settlement:** A high-rise's immense weight causes slow, uneven foundation settling, inducing stress on the superstructure, leading to tilt and internal fracturing undetectable without precise monitoring.

Contact:
info@structureIQ.ai
W: www.structureiq.ai



StructureIQ Solution offers continuous, data-driven risk assessment

- **Structural Instability**: Monitors vibration and accelerometry to detect issues from weakened joints or hidden damage.
- **New Construction:** Ensure that the as-built construction meets the design specifications.
- **Seismic Response:** High-frequency sampling during sudden or seismic events assesses structural impact.

Real-World Failures: The Case for Continuous Structural Monitoring

Champlain Towers South (USA) — The Failure of Concealed Corrosion

- Incident: The sudden, partial collapse of a 12-story beachfront condominium in Surfside, Florida, in 2021, resulting in 98 fatalities.
- Root Cause: Long-term water infiltration led to severe, hidden corrosion of reinforcing steel within the concrete pool deck slab and critical columns, silently compromising load-bearing capacity over decades.
- Relevance: Critical degradation occurred in concealed areas hidden by finishes or buried in concrete. Continuous monitoring could have detected the weakening before the catastrophe.

Opal Tower (Australia) — The Failure of Precast Connections

- Incident: A 36-story residential high-rise in Sydney was evacuated on Christmas Eve 2018 after residents heard loud cracking noises and large fissures appeared in precast concrete panels.
- Root Cause: An investigation found that design flaws and construction defects in hob beams and connections led to localized structural failure under normal loads.
- Relevance: The degradation occurred in structural elements hidden behind finishes.

APPLICATION NOTE: Commercial Building Structural Monitoring

StructureIQ's implementation strategy for buildings

StructureIQ provides A low sensor density for effective continuous safety monitoring or a high sensor density for precise damage localization. This high-resolution approach ensures that all structural elements are monitored. The deployment schematic shows a low density wireless sensor set up on key load paths, detecting changes in localized movement due to fatigue or degradation. These high-precision tri-axial accelerometers monitor inter-story drift, global sway periods, and foundation tilt during extreme weather or seismic events, as well as the effects of degradation occurring over time.

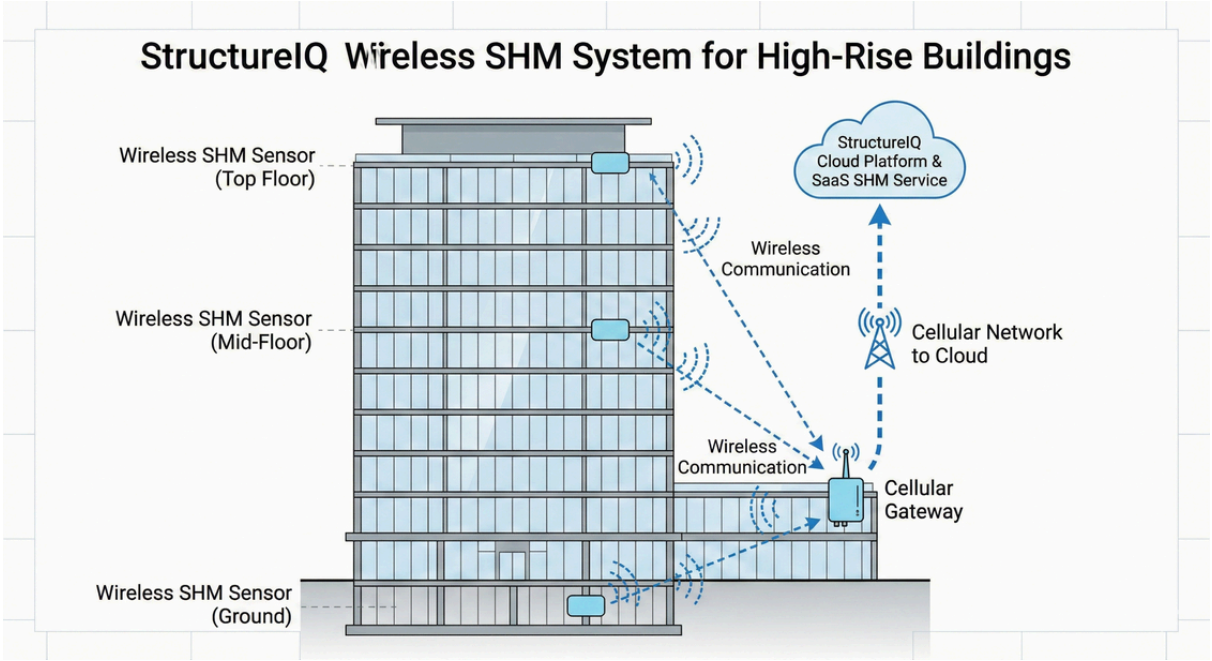


Figure 1.

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

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W: www.structureiq.ai

Benefits & ROI: The Value of High-Fidelity Data in Vertical Real Estate

Switching to a high-resolution sensor array turns the SHM system into a strategic asset management tool for valuable real estate.

Precision Maintenance vs. Guesswork

This data enables facility managers to direct maintenance crews to precise problem zones, eliminating costly and disruptive inspections.

Liability Shield & Due Diligence

In commercial real estate, uncertainty is a liability. Continuous, granular data provides an immutable digital audit trail, proving the structure performed within safety parameters and demonstrating due diligence to insurers, regulators, and occupants.

Asset Value Protection & Life Extension

High-rise buildings are significant capital investments intended for long-term use. Continuous monitoring helps owners manage trends like differential settlement, identifying issues early to defer major expenses and maintain market value.

Conclusion

Vertical infrastructure worldwide is facing a crisis of aging materials and increasing environmental loads. Incidents like Champlain Towers South and Opal Tower illustrate that relying solely on traditional visual inspections for high-rises allows "silent" threats buried within the structure to go undetected until failure mechanisms activate. However, the resilience of these investments can be secured through proactive technological intervention. StructureIQ bridges the gap between physical inaccessibility and the need for critical insight. By deploying a scalable, high-resolution wireless sensor network, building owners give a "voice" to silent superstructures, transitioning from uncertainty to data-driven assurance. This ensures high-rise buildings remain safe for occupants and valuable assets for investors.

References

1. Champlain Towers South: National Institute of Standards and Technology (NIST). (2023). Key Findings of the NIST Technical Investigation of the Champlain Towers South Collapse. U.S. Department of Commerce.
2. Opal Tower: NSW Government Planning & Industry. (2019). Opal Tower Investigation Final Report. Independent Investigation led by Professors Hoffman, Carter, and Foster for the New South Wales Government.