Recent Developments in Laser-Based Optical Sensor Systems for Seismic Monitoring of Critical Infrastructure

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Advancements in sensor technologies and communication networks are creating new opportunities for advanced methods of measuring earthquake response and damage in critical infrastructure systems. Based on DOE sponsored applied R&D, new optically-based sensor systems have been developed that provide for continuous measurement and rapid transmission of key infrastructure response observables immediately after an earthquake. The short latency of the underlying physics in optical sensors, and the ability to perform high resolution measurements across a broad frequency bandwidth are attributes that make optical-based measurement systems particularly effective for applications in infrastructure earthquake response measurement. Concurrently, transformational progress underway in wireless communications and the Internet of Things (IOT) are enabling new paradigms for expedient deployment of sensor systems and rapid extraction and analysis of time-critical data.

Building interstory drift is a key earthquake response observable for building structures and is broadly utilized as a design parameter in many engineering standards to define performance-based limit states, maximum allowable story deformations, and quantification of damage in post-earthquake assessments. Historically, drift measurement has been obtained through signal processing and double integration of accelerometer data, which is inherently challenging and typically subject to significant frequency bandwidth limitations, particularly if inelastic, permanent drifts occur. To date, there has been no widely accepted methodology or technology for reliable and accurate direct measurement of building drift.

In this presentation, recent advancements in a new optically-based sensor system for direct measurement of interstory drift are presented. The third generation of a *Discrete Diode Position Sensor* (DDPS), which utilizes laser light to directly measure drift, is described and data from recent experimental tests illustrating high-resolution sensor performance is presented. The ability to measure both Transient Interstory Drift (TID(t)) and Residual Interstory Drift (RID) with measurement errors in the sub-millimeter range is demonstrated. To facilitate efficient deployment of the optical sensor systems, a practical, wireless mesh network for reliable, rapid extraction of building data has also been developed. The mesh network is based on a system of dedicated low-power radio-frequency (RF) nodes that can self-configure and form a dynamic network throughout a building structure. The first successful field deployment of the optical sensor and mesh communication network are described for a DOE mission-critical facility in the San Francisco Bay Area.