Structural Health Monitoring: Past, Present and Future

Achintya Haldar, Dist. M. ASCE, Fellow, SEI
Professor and da Vinci Fellow
Department of Civil Engineering and Engineering Mechanics
University of Arizona, Tucson, AZ

Structural health assessment, monitoring, and management have attracted interdisciplinary research interest all over the world. Infrastructures are deteriorating, some of them are beyond their design life, or they are being exposed to extreme events like strong earthquakes, high winds, or man-made explosions. Due to shortage of resources to replace them, it is now necessary to extend their design life without exposing public to unnecessary risk. One attractive option is to inspect the infrastructures thoroughly in a timely manner to identify the defect locations, quantify their severity and then take appropriate remedial actions for continued useful service. It is also expected that the necessary inspections should not disrupt the normal operation of the structure. Researchers from many different disciplines are developing inspection methods, necessary sensors and their optimal implementation in field conditions, and data collection, fusion and analysis techniques. Some of the concepts are based on the structural behavior at the time of inspection and use measured static and dynamic responses. They are offline and/or online, but most are not suitable for large infrastructure systems. In spite of many significant developments, their applications to assess the health of existing infrastructures have been limited. There are numerous challenges and implementation issues that still need to be addressed.

The speaker and his team members have conducted extensive theoretical, analytical, and experimental investigations during the past two decades, identified several challenges, and proposed solutions and implementation strategies. Combining sensor data with finite element analysis, the structural health can be assessed, in terms of locations and severity of damage, by tracking the stiffness properties of the elements and comparing them with observations in past inspections, if available, or using information from the design and drawings, or studying deviations from other elements with similar properties. The information can be extracted from the signatures embedded in a few noise-contaminated acceleration time histories measured at small segments of the structure, only for very short durations and even without the excitation information. Different Kalman filter-based algorithms have been significantly advanced. The presentation will address recent developments and ongoing challenges in structural health monitoring, drawing on the speaker's recent research supported by the U.S. National Science Foundation (CMMI-1403844).