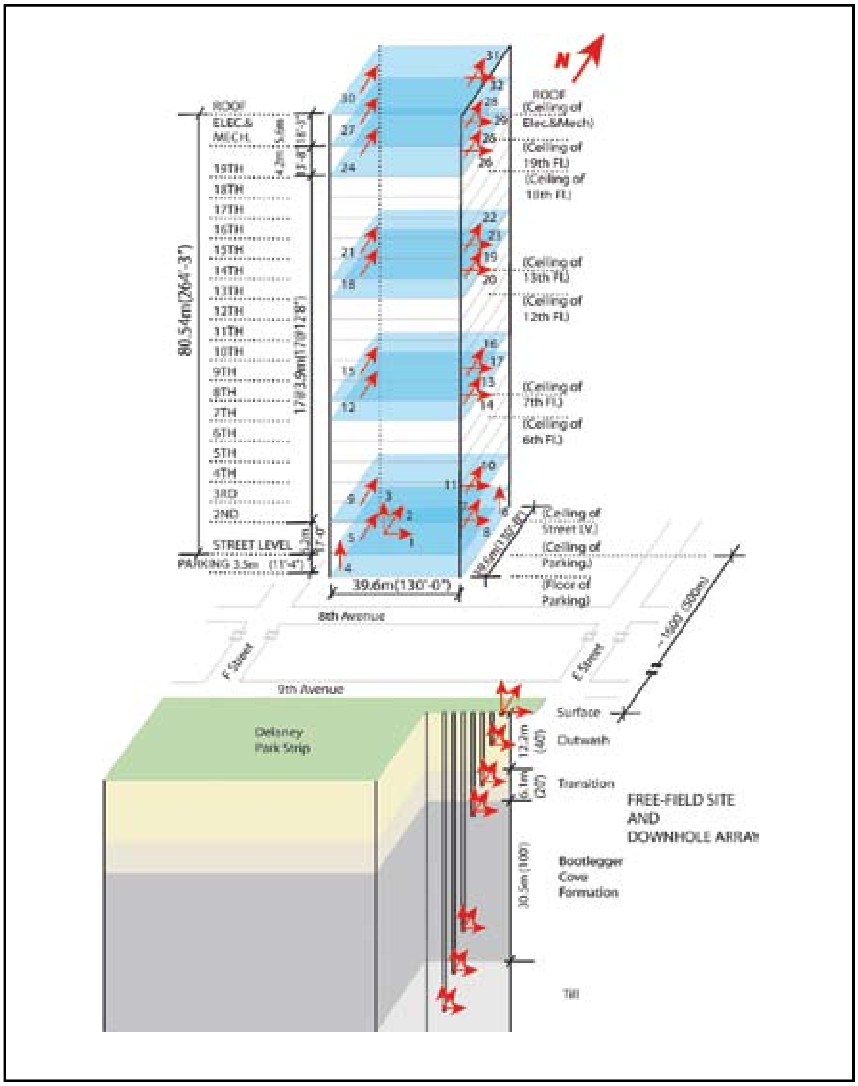
The Advanced National Seismic System

Structural Monitoring To Improve Understanding of Seismic Performance

By William Leith, Ph.D.



The Atwood Building in Anchorage, Alaska, was extensively instrumented through ANSS, with 32 strong-motion accelerometers distributed across ten levels of the 20-story structure, plus a nearby, nine-element subsurface array designed to collect data on input ground motions. Courtesy of Mehmet Celebi, USGS.

Earthquake-resistant buildings and other structures are the first line of defense in reducing losses from earthquakes. To improve building safety, better knowledge is needed of both the ground shaking and the performance of structures subjected to strong earthquake shaking. The Advanced National Seismic System (ANSS) operated by the U.S. Geological Survey, is providing this improved knowledge through its monitoring of earthquake ground shaking and structural response.

More Earthquake Data Are Needed

Earthquake engineers, including both structural and geotechnical specialties, work to understand how structures perform when strongly shaken by earthquakes. Their goal is that existing structures can be retrofitted and new structures can be built with improved methods and codes to greatly reduce future earthquake damage.

Thorough understanding of how a structure responds to strong ground shaking is limited today by the scarcity of earthquake recordings within structures. Currently, few buildings in the United States have been extensively instrumented to record their performance during earthquakes. This scarcity of data means that engineers must infer the characteristics of structural response to earthquakes when they design buildings. Application of laboratory test data is problematic because of difficulties simulating realistic building conditions. Consequently, actual earthquake data are needed to improve seismic design.

Collecting Critically Needed Earthquake Response Data

Since 2000, the U.S. Geological Survey (USGS) has provided initial funding for a national program to improve ground and structural recording of earthquake-induced shaking in high-risk urban areas. This effort, known as the *Advanced National Seismic System* (ANSS), has an eventual goal of placing 9,000 sensors in buildings and other engineered structures around the United States, plus 3,000 ground sensors to obtain accurate measures of shaking across 26 at-risk urban areas. Together, these structural and ground response monitoring systems will provide earthquake engineers with data to improve structural designs and, hence, performance. Much of the development of this system is being leveraged by contributions from states, educational institutions and the private sector.

Ground-motion recordings from these networks of sensors in regions of moderate-to-large earthquakes are essential input to predictive models of structural response. Equally essential are extensive recordings from within buildings, bridges, and other structures (pipelines, dams, port facilities), which can be used to evaluate performance, to improve post-earthquake damage assessment, and to improve future structural designs. These data are critical to the evolution of performance-based earthquake engineering, through which structures are designed with predictable and defined seismic performance (see *VISION 2000*, SEAOC, 1995).

An important parallel effort is the *Network for Earthquake Engineering Simulation* (NEES, **www.nees.org**), an NSF facility supporting advanced research, experimentation and simulation of the ways buildings, bridges, utility systems and geomaterials perform during seismic events.

Monitoring is in Progress Now

The Atwood Building in Anchorage, Alaska, is an example of current ANSS monitoring. The building is instrumented with 32 accelerometers distributed across ten floors of the 20-story structure, designed to measure important features of response including rotation and interstory drift. There is also a nearby geotechnical array designed to collect data on input ground motions at the ground surface and at various layers in the soil profile. High-resolution digital data are collected from ambient vibrations, small earthquakes, and large earthquakes. These valuable data are openly provided to researchers and practitioners alike.

Structures like the Atwood Building are selected for instrumentation based upon their potential for providing useful data to the engineering community. Guidelines followed in this selection process can be found at: **earthquake.usgs.gov/research/monitoring/anss/docs/ANSS Guideline_civil.pdf.**

Downstream Economic Benefits

In 2003, the USGS commissioned a study by the National Research Council (NRC) on the economic benefits of improved seismic monitoring. Specifically, the USGS asked the NRC to examine how improved monitoring could reduce future losses and to estimate the benefits that could be realized by the full deployment of ANSS.

The NRC report is available at: **www.nap.edu/openbook.php?isbn=0309096952**.

The NRC's blue ribbon committee found that seismic monitoring provides the key to understanding how the built environment responds to significant earthquakes, and specifically that detailed structural response data offer the potential for fine-tuning the design process so that seismic safety requirements are adequately – but not excessively – met. The NRC panel estimated a total building-related annualized loss avoidance of $142 million per year, nearly three times the projected annual costs of operating the full ANSS.

The Bottom Line

When ANSS is fully implemented, hundreds of structures will be extensively instrumented with the goal of obtaining their response to strong earthquake shaking. Through this effort, the USGS and cooperating agencies and organizations are poised to greatly expand strong-motion recordings in high-risk urban areas, both on the ground and in buildings, bridges, and other structures. This will provide the earthquake engineering community with the data it needs to improve seismic design practices and thereby reduce future earthquake losses.▪

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