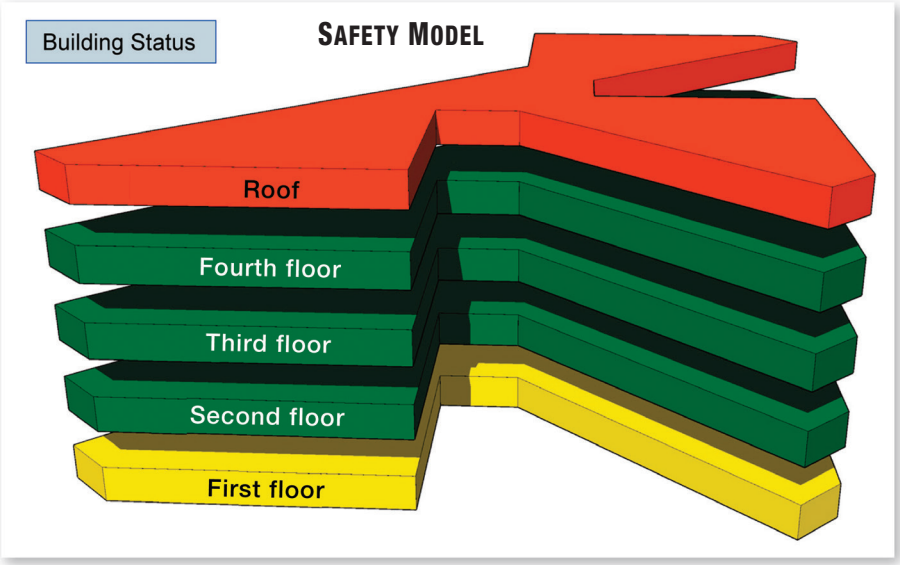

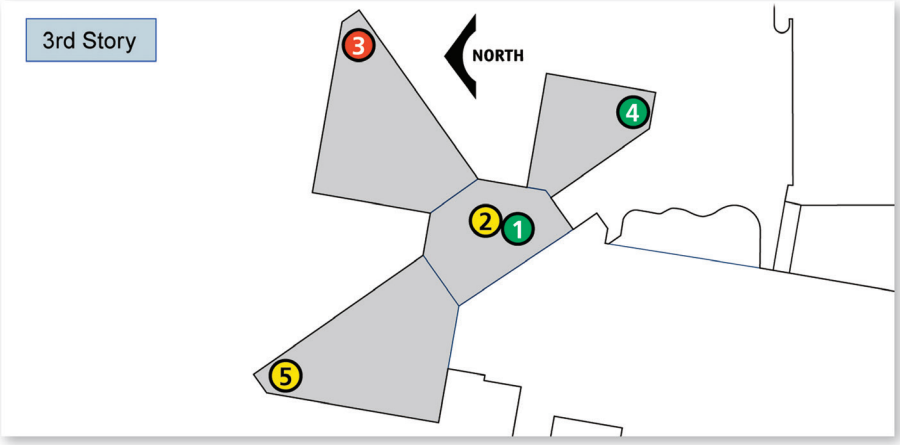

Data from accelerometers are transmitted to a computer, which processes the information and plots the results as different colors within a wire frame model of the building. Green denotes that an area is safe, yellow means safe with restricted use, and red means unsafe.

Program Accelerates Postearthquake Evaluations

IN FEBRUARY 2001, when the Nisqually earthquake rattled the state of Washington, the scene at Naval Hospital Bremerton was chaotic. Light fixtures fell from the ceiling, a sprinkler pipe ruptured, and water dispensers and bookcases toppled. The earthquake had a magnitude of 6.8 and badly disrupted work at the hospital, but it wasn't immediately clear whether the temblor had damaged the building's steel moment-resistant framing. Hospital administrators turned to the facilities department head to determine whether to evacuate.

Russell Kent, P.E., had not been in his position as head of the hospital's facilities management department long at that time, and many members of his team also were new. Unfamiliar with the intricacies of the nine-story, concrete-clad building, Kent and his team were unsure how to proceed. "One of the first concerns of the hospital administration was, is the building safe?" Kent recalls. "Frankly, neither I nor my staff had the knowledge necessary to make that kind of decision.... We really didn't know how to figure that out either, because the [structural framing] is largely invisible." As Kent and his team attempted to survey the building, firefighters arrived on the scene and recommended that the hospital be evacuated. "They saw that the building looked kind of hazardous, and so the conservative approach was to evacuate," Kent says.

But evacuating a hospital is no simple task, and moving critically ill patients involves a great deal of risk. For that reason, hospital administrators proceeded with only a partial evacuation, moving patients not in extremely critical condition to an adjacent field hospital that was being used to train personnel for work in Iraq. At the same time, a team of engineers from the Naval Facilities Engineering Command arrived at the hospital and began investigating the structure. "They had a little bit better feel for what sort of things visibly would constitute structural damage, and within a few hours we had a pretty good idea that we in fact did not have any serious structural concerns," Kent says. Those findings were confirmed months later when film from an old seismograph that had been installed in the building in the 1970s was processed, the moment-resisting frame connections were tested, and other structural analysis was performed.

The experience taught Kent the importance of being prepared for an earthquake. "The real lesson for me and for our staff was that we needed a way in a future earthquake to come to a conclusion [about the hospital's condition] much faster than two hours," Kent says. "We needed to have some kind of idea within a few minutes." Kent and his team began working with Reid Middleton, Inc., an engineering firm based in Everett, Washington, to improve their earthquake response. The firm trained Kent and his team on procedures based on manuals developed by the Applied Technology Council (ATC) to evaluate earthquake effects. In particular, the procedures used the manuals ATC-20 (*Procedures for Post Earthquake Safety Evaluation of*

REID MIDDLETON, INC., *BOTH*

Buildings) and ATC-21 (*Rapid Visual Screening of Buildings for Potential Seismic Hazards*), and over the course of several years Reid Middleton carried out a seismic upgrade of the hospital.

As Reid Middleton's staff worked with Kent, they realized his case was not unique and that there was a pressing industry-wide need for accelerated postearthquake evaluations. To meet the need, Reid Middleton developed what it calls the Rapid Evaluation and Assessment Program (REAP), which combines proven seismic sensor technology with a customized building assessment portfolio. With REAP, building managers can promptly determine whether or not their buildings are structurally stable after an earthquake. "It's like an owner's manual that enables a facility manager to do an eight-hour assessment in an hour," says Dave Swanson, P.E., S.E., LEED AP, M.ASCE, a principal of Reid Middleton.

REAP has two components. The first is a modern seismic monitoring system comprising accelerometers and an industrial-grade computer connected to an uninterruptible power supply. The accelerometers are strategically placed throughout a building to measure movement as it occurs. Data from the accelerometers are transmitted to the computer, which determines displacements, velocities, and accelerations. The results are then plotted as different colors within a wire frame model of the building, green denoting safe, yellow safe for restricted use, and red unsafe. "As the building's actually shaking, it's all being measured, recorded, processed, and put on a computer screen," Swanson says. The results give an indication of a building's condition, but they do not obviate the need to visually inspect the structure. "You can't just put these sensors in buildings and then walk away," Swanson says. "You really need a pair of eyes looking at the structure."

To that end, the monitoring system serves as a companion to the program's other component, a customized building assessment portfolio. Based on accepted earthquake evaluation standards and on performance-based earthquake engineering criteria, the portfolio contains information pertaining to a particular building that is intended to facilitate the visual inspection. That information includes such elements as drawings, architectural and structural characteristics, preearthquake photographs, setback features, and water shutoff locations. A checklist and flowcharts also are included to remind building engineers what to look for after an earthquake. "It's designed to act as a memory guide for us so that during the stress of an earthquake or the events afterward, we can pick up that book," Kent says. "It starts with a walk around the building, looking at the exterior and then looking at critical areas like egresses and then moving into the building itself."

REAP has been implemented not only at the Naval Hospital Bremerton but also at the Naval Medical Center San Diego; the Robert E. Bush Naval Hospital, in Twentynine Palms, California; and a strategic weapons facility near Seattle. Reid Middleton hopes to deploy the system to other hospitals, federal facilities, and privately owned structures in the future. "The kind of vision that I have for the program . . . is that it would be mandated to be part of essential facilities like hospitals and schools because those buildings are key to recovery following a disaster," Swanson says. The program may also be valuable to such businesses as Amazon, Boeing, and Microsoft, which could suffer grave financial losses if communications were disrupted by an earthquake. The $200,000 or so that it costs to implement REAP is nothing compared with the money that could be lost, Swanson says. "Those...tools give the building owner or manager the ability to keep the facility up and running and not have to evacuate it," he says. "Or if they decide to evacuate it, it's for a very good reason. It's not due to uncertainty. We're trying to reduce the uncertainty."

Kent knows that, with REAP, the next time an earthquake strikes he and his team will be better prepared to quickly evaluate the hospital to determine whether to evacuate. "Being prepared for an earthquake is kind of easy to put on the back burner for years," he says. "But I can tell you, having gone through it myself and facing the [question] of…whether the building is safe and not being able to answer that question…I don't want to be in that position again…. We need to be able to answer that question when it happens."

—JENNY JONES

Naval Hospital Bremerton is one of several facilities that have used the Rapid Evaluation and Assessment Program, which combines proven seismic sensor technology with a customized building assessment portfolio.