Robotic inspections

The Electric Power Research Institute (EPRI) is integrating inspection techniques with robotic technology to improve the assessment of vertical structures, including dam walls.

For inspections of concrete on dam structures, accessibility can be a major challenge. Surface inspections often require the use of extensive scaffolding and rope systems, exposing workers to potentially hazardous working conditions.

There is little doubt that inspections could be carried out in a safer, more efficient manner with the use of robotic machines. Although existing machines on the market could be used for inspection purposes with some modifications, they may not be suitable for the large vertical surfaces found on dam structures.

As a result, EPRI put out a request for proposals for robotic technology that would be rugged enough for outdoor deployment, equipped with enough battery or independent power to operate for four days; flexible enough to carry a variety of inspection devices to detect different types of flaws; and able to traverse rough surfaces.

A range of ideas were submitted, and EPRI’s choice for further evaluation was a concrete crawler from International Climbing Machines, which was designed to negotiate concave, convex, or overhanging vertical structures while carrying more than 40 pounds of equipment.

Held to the surface by vacuum force, the crawler has been designed to adhere to essentially any hard surface. The patented, highly flexible seal ensures the machine is securely adhered as it moves the machine over surface obstacles such as bolt heads, plates, weld seams, and other surface irregularities. The vacuum chamber is surrounded by a rolling foam seal that guards against leakage and facilitates propulsion.

The crawler, which is essentially a remote-controlled climbing vehicle, now acts as a platform for automated inspection and advanced nondestructive evaluation (NDE) of major concrete structures at power plants. Integrated with onboard systems including simultaneous localization and mapping (SLAM) technology and advanced NDE instrumentation, the crawler can conduct automated, high-precision inspections and capture computer-encoded data and images.

That data will support real-time condition assessment and long-term monitoring of degradation and aging processes to guide maintenance decisions and risk-informed management of hydro assets.

Demonstration project

In July this year, EPRI, in collaboration with New York Power Authority (NYPA), American Electric Power, Exelon, the Southwest Research Institute, International Climbing Machines, the University of Texas at Austin and Rutgers University, put the concrete crawler to the test at NYPA’s Niagara power plant.

The robot was attached to the dam wall and was controlled using a commercially available controller. As part of the test, the team used an acoustic sensor to check for delamination, and used a mapping system for positioning.

“When you’re taking data on structures such as this, you want to know where you are on the structure, so you have to measure it with a tape measure,” said Michael Blanton, Southwest Research Institute. “With a mapping system you alleviate that manual inspection process. Every little shift in the robot, every little turn, you’re able to pick that up and track it. We saw exactly what we needed to see.”

Other technology demonstrated included air-coupled echo technology, and infrared thermography. “Infrared thermography is where we use a thermal camera to look at the heat that is being emitted from a structure, and that can tell us a lot about what’s there, whether its delamination, or if a repair is good or bad,” commented Jeramy Renahaw of EPRI.

“Essentially, we can do a rapid screening of the entire dam, and then go back with a more detailed precise inspection, with something that could be installed on the crawler over a smaller area.”

Future plans

The tests allowed the research team to identify potential improvements to the system, such as a new control system. Maria Guimaraes, senior project manager at EPRI, said that the team will eventually be able to use an iPad to control the crawler. “We are currently developing the iPad communication system so users will be able to control all aspects of the crawler from a single interface.”

Other improvements being planned include reducing the size of the sensor payload and equipping the crawler with a variety of interchangeable sensors. There is also the potential to use technologies that are not typically used in the assessment of structures, for example moisture measurement.

A fully functional first-generation prototype will be constructed and evaluated in diverse industry settings during 2014. Further refinements and field tests are expected to lead to the development of specifications for a commercial inspection robot that could deliver unprecedented insights on concrete degradation and aging processes.

“We are in the initial phase of testing, but this device shows great potential for advancing the industry’s concrete inspection process,” concluded Maria Guimaraes. “By the end of the year we’d like the data that can be collected by this robot to provide a real-time, accurate assessment of the conditions and integrity of concrete.”

A call to action

Updates on the concrete crawler are provided on www.epri.com and through the advisory structures of the Technology Innovation Program and the Nuclear, Generation, and Environment & Renewable Energy sectors. EPRI seeks utilities and vendors to support development and field demonstration of autonomous, highfidelity inspection technology for cooling towers, hydro dams, and reactor containment structures.