Drones, new kinds of sensors and advances in current technologies are making bridge inspection work faster and safer.
TAKING A CLOSER LOOK AT BRIDGES

Drones provide unprecedented access and new techniques allow extensive analysis, but final decisions still call for a trained human eye

By Aileen Cho

Ted Zoli, national chief bridge engineer with HNTB, compares bridge inspections to taking his kids to the doctor. “Every few years you take another set of pictures of the bridge, and ultimately you can pattern it. You pay attention in a deeper way to responses, and have a record.” But like parents who don’t want to send kids to the doctor at the first sign of a sniffle, once managers understand the characteristics of a bridge and its behavior, they don’t need to do constant in-depth reinspections. They are constantly looking for ways to make better decisions with the data they already have. “We spend a lot of money inspecting bridges,” says Zoli. “The question becomes whether there is a more technologically efficient way to do it.”

Drones are part of the answer. On Dec. 5, Intel announced its collaboration with the Minnesota Dept. of Transportation and the Kentucky Transportation Cabinet applying Intel’s advanced commercial drone solutions—including preflight planning software, the Falcon 8+ drone and post-processing data management—to inspect complex bridge infrastructure. Intel’s software is used to design the flight plan and image capture locations. That mission can be duplicated year after year for subsequent missions, giving inspectors an “apples-to-apples” comparison of the bridge’s changing quality and potential deterioration, says the company announcement. The drone can capture detailed aerial data for 3D reconstruction, down to millimeter accuracy for ground sample distance. Used for an asset like a bridge, the technology can also help inspectors connect multiple data sets to the infrastructure asset, giving engineers the ability to monitor changing conditions over time. Each asset and its data easily can be recalled by name, location and date, according to the Intel release.

Paul McGuinness, bridge inspection lead with Michael Baker International, which has been involved with the Kentucky part of the Intel drone-inspection collaboration, says that feedback has been positive so far. “Drones are not replacing [manual] inspections, but they’re a screening tool before going in for a physical inspection,” he says.

The drone supplemented the work of Michael Baker’s rope-climbing inspectors—and that technology, too, has undergone improvements. “We’ve doubled productivity using power seats,” he says, describing a power-assisted ‘bosun’s chair’ Michael Baker’s inspectors have started using to speed up aerial inspections. “You feed the rope through the seat and ascend the cable, rather than rappelling. You can inspect going both up and down. It’s twice as fast and doesn’t fatigue the climbers,” he says.

Finn Gottfredson, project director, Bridges Scandinavia for COWI Denmark, says his bridge engineering firm has developed its own drone-based virtual inspection tool over the last two years. “For many years, we have been taking pictures from planes to make digital models. We thought we could do something similar during inspections,” he says.

FLYING HIGH
A drone hovers above the Daniel Carter Beard Bridge over the Ohio River in Cincinnati (right).
The firm inspected two anchor blocks on the Storrs-belte, a major suspension bridge in Denmark, and used both close-up and distance photos to create specialized 3D models. The camera’s direction of view and the position of the drone relative to the bridge all can be seen in the model, which helps engineers making observations and notes in the model better understand what they are seeing and where the issue is in relation to the whole structure. “We used these models to navigate—you could easily lose the feel of where you are when you look at pictures. You can draw a circle around your observation and register it in a database.”

COWI is working on incorporating such model-inspection evaluation data into an asset management system, says Gottfredson. “Asset management systems and building information modeling will merge in the years to come,” he predicts.

Unusual Sensors

Ed McSpedon, a lifelong civil engineer, decided to help out a startup with Metal Fatigue Solutions, that targeted the infrastructure market with two new types of sensors. “I couldn’t have picked a more difficult market for a startup. Our industry is not the most open to change and innovation,” he says. “Many clients are in government, so there’s no reward to be innovative. Nobody wants to be first, but nobody wants to be last, either.”

One of the sensors is an electrochemical fatigue sensor. It is placed on a bridge crack, and a cavity inside the sensor is filled with an electrolyte that creates a passive layer of rust atop the steel. If the crack begins to grow, it opens up a previously unexposed steel layer and changes the current flowing through the electrolyte coating, alerting inspectors to the crack’s growth. “We used to just look for voids. Now we need more comprehensive techniques that would allow for finding the corrosion without voids. You could use ultrasonic guided waves or acoustic emissions to listen for fiber breaks,” she says.

Scour is another issue that is being addressed. A company named Sensor Monitoring Solutions uses three accelerometers and tilt meters positioned in two directions to monitor pier movements during a high-velocity water event, says Miceli. What are those forces? When looking at absolute tilt, she asks, “Did the pair come back to its original place?”

Last January, a crack in a truss on the Delaware River-Turnpike Toll Bridge, an arched steel, four-lane, continuous truss bridge crossing the Delaware River between Burlington Township, N.J., and Bristol Township, Pa., led to a temporary closing. That gave Ashley Thrall, associate professor of structural engineering at the University of Notre Dame, and her student Yao Wang a chance to use three-dimensional “digital image correlation” for stress analysis.

Drowning in Data

With the evolving technologies comes the issue of interpreting the data. “I’d like to see improvements in quantifying data; there’s a bit of a gap right now,” says Bernard Kassner, research scientist with VDOT.

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—ED MCSPEEDON, BRIDGE ENGINEER, ON PUBLIC AGENCIES TRYING NEW INSPECTION TECHNOLOGIES
cessing power, sophistication of current software and the analytics involved have all allowed for more powerful usage of data. “We are looking at augmented reality, photogrammetry and lidar. We’ve experimented a bit with HoloLens and how inspectors could utilize that to pull up data of a bridge on site. It’s all rapidly evolving—but it’s still evolving,” he says.

No matter how evolved, sensors, drones and other techniques will only augment, not replace, human inspections. “Visual inspections are still important and will remain that way for a long time,” says Soundar Balakumaran, VDOT research scientist. “I’d like to see technologies that can augment human participation in the nondestructive testing stages.”

Williams adds that “countless times we’ve seen what looks like a beam end with some scaling rust, but it looks solid, and if you take a picture or video … that’s what it shows. Then you tap it with a hammer and a 6-inch piece falls out.”

This makes the point, Williams says, that there is no substitute for tactile inspection and a human eye trained to understand what that patch of scaling rust means and how urgent the finding is. The process requires an understanding of bridge mechanics, he says. “Perhaps some tasks could be automated, but the final decision point needs humans.”

Engineers say that anything leading to improved safety and efficiency in inspections is desirable. “We need reliable remote access,” says Williams. “If there was a way to equip a crawling drone or aerial drone or underwater drone, the sensor capability would not just show the surface, but give a penetrating view to show subsurface deficiencies. It would allow us to zero in on areas requiring hands-on follow-up. For example, we have a truss bridge over a mile long. Rather than traditional methods, we could utilize remote technologies to know in advance what areas to look at.”

As engineers seek to merge existing practice with emerging technologies, it looks like autonomous drones and integrated analytics will play a big part. But Cindy Ng, head of marketing for Intel’s drone group, believes drones also will need autonomy, intelligence and advanced flight safety technology built in so that bridge inspection operations can be executed automatically without a pilot.

“I’d like to see drone technology make it easier and more effective to conduct bridge inspections on a repeatable and regular cadence so that motorists, commuters, tourists and pedestrians won’t have to wonder if the bridge they’re crossing is safe,” Ng says.

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ASSESSING THE DATA
Technologies such as drones are augmenting the inspection process, but engineers also see the need to better manage data that is generated.

WE NEED RELIABLE REMOTE ACCESS, BUT THERE’S NO SUBSTITUTE FOR TACTILE INSPECTION.
—CHRISTOPHER WILLIAMS, VIRGINIA DOT

Cover Story
Inspection Tech

Michael Baker International

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