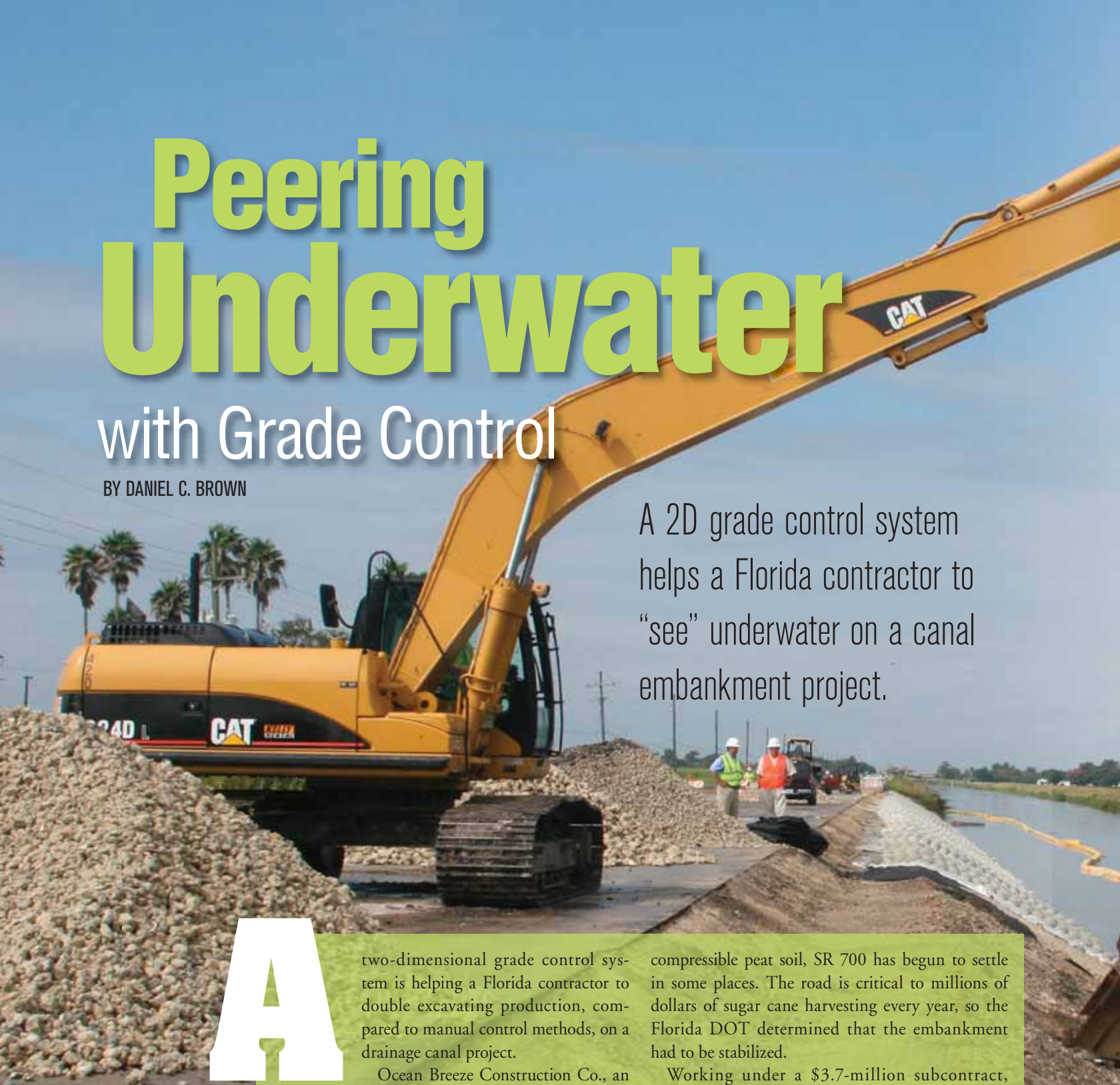
Peering Underwater with Grade Control

BY DANIEL C. BROWN

A 2D grade control system helps a Florida contractor to "see" underwater on a canal embankment project.



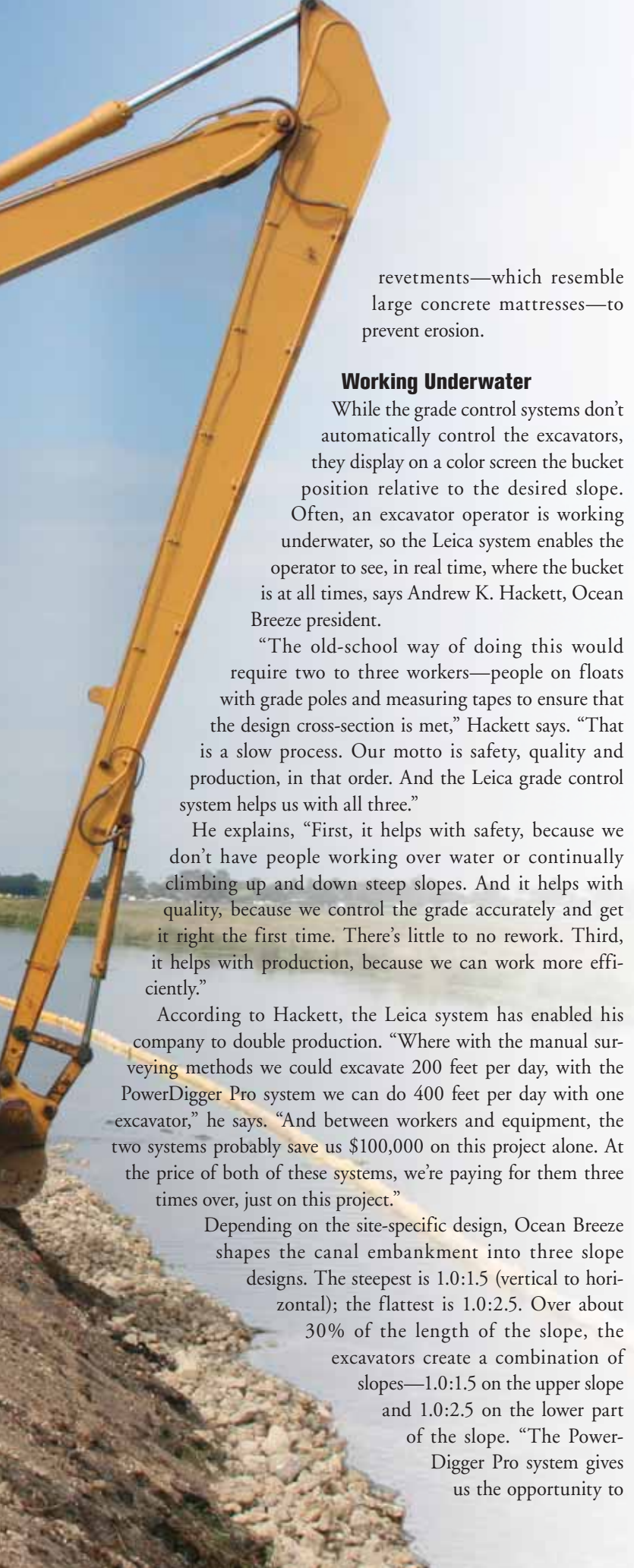
The long-boomed excavator finish-grades a canal slope alongside State Route 700 in Florida.

A two-dimensional grade control system is helping a Florida contractor to double excavating production, compared to manual control methods, on a drainage canal project.

Ocean Breeze Construction Co., an erosion control specialty firm in business since 1981, is using the grade control system on a 14-mile section of erosion control work on the canal. The canal is 14 feet deep by 125 feet wide and runs alongside State Route 700 just outside Wellington, Florida.

As canal water flows east from Lake Okeechobee, it erodes the roadside embankment in places and threatens the structural integrity of the two-lane roadway. Because the road's subgrade has a layer of compressible peat soil, SR 700 has begun to settle in some places. The road is critical to millions of dollars of sugar cane harvesting every year, so the Florida DOT determined that the embankment had to be stabilized.

Working under a $3.7-million subcontract, Ocean Breeze is shaping the canal embankment according to a design that calls for various templates and slopes. Two long-boom Caterpillar excavators, a Cat 324D and a Cat 325B, were each fitted with PowerDigger Pro grade control systems from Leica Geosystems to handle the clearing, channel excavation, embankment fill and final grading. In 27 areas ranging from 50 to 5,000 feet long, the contractor is installing rock fill and cast-in-place concrete block



revetments—which resemble large concrete mattresses—to prevent erosion.

Working Underwater

While the grade control systems don't automatically control the excavators, they display on a color screen the bucket position relative to the desired slope. Often, an excavator operator is working underwater, so the Leica system enables the operator to see, in real time, where the bucket is at all times, says Andrew K. Hackett, Ocean Breeze president.

"The old-school way of doing this would require two to three workers—people on floats with grade poles and measuring tapes to ensure that the design cross-section is met," Hackett says. "That is a slow process. Our motto is safety, quality and production, in that order. And the Leica grade control system helps us with all three."

He explains, "First, it helps with safety, because we don't have people working over water or continually climbing up and down steep slopes. And it helps with quality, because we control the grade accurately and get it right the first time. There's little to no rework. Third, it helps with production, because we can work more efficiently."

According to Hackett, the Leica system has enabled his company to double production. "Where with the manual surveying methods we could excavate 200 feet per day, with the PowerDigger Pro system we can do 400 feet per day with one excavator," he says. "And between workers and equipment, the two systems probably save us $100,000 on this project alone. At the price of both of these systems, we're paying for them three times over, just on this project."

Depending on the site-specific design, Ocean Breeze shapes the canal embankment into three slope designs. The steepest is 1.0:1.5 (vertical to horizontal); the flattest is 1.0:2.5. Over about 30% of the length of the slope, the excavators create a combination of slopes—1.0:1.5 on the upper slope and 1.0:2.5 on the lower part of the slope. "The PowerDigger Pro system gives us the opportunity to be exact—to know the horizontal and vertical dimensions from the safety of the operator's cab," Hackett says.

The Leica system works from four sensors mounted on the excavator. One is mounted on the boom, another on the stick, another on the bucket and the fourth, mounted behind the cab, monitors pitch and roll. With information from the sensors, an on-board computer triangulates the X and Y coordinates of the bucket edge. An in-cab display then shows the operator the horizontal reach of the bucket, the depth and the grade, or slope.

"One screen shows the design slope, and all the operator has to do is put the bucket on the design slope and follow it," says Greg Fearon, vice president of LSR Inc., the local Leica dealer. "For elevation control, a separate remote display shows the operator whether the bucket is too high, too low, or right on."

Hackett says he started the project with one PowerDigger Pro system on just one excavator—the "smart" excavator—and used the second machine as a "dumb" excavator. "The dumb machine would do the clearing and rough excavation and the smart machine would do the fine grading. So we said, 'Why not educate the dumb machine into a smart one, and then it would not be working blind during the mass excavation and could go right to the fine grading template?' We bought a second system, and it makes us look back and say, 'How did we manage to do this without an electronic grade control system for the past 28 years?'"

Quality Control

Coordinates supplied by the grade control system are used for interim quality assurance, Hackett says. "For inspection purposes we will write down the X and Y coordinates of the finished grade directly from the grade control system's onboard screen. Those will be plotted and submitted to the consulting inspector who works for the DOT. The DOT hired C3TS to act as the owner's agent to ensure that the embankment line and grade is acceptable

Project Stakeholders

Owner: Florida Department of Transportation, District IV
Construction manager: C3TS (Corzo Castella Carballo Thompson Salman), Wellington, Florida
Prime contractor: Ranger Construction Industries Inc., West Palm Beach, Florida
Revetment subcontractor: Ocean Breeze Construction Co. Inc., Palm Beach Gardens, Florida
Revetment engineer: Soil Reinforcement Design Inc., Woodstock, Georgia
Revetment supplier: Synthetex Inc., Atlanta, Georgia
Equipment dealer: Kelly Tractor Company, Miami, Florida
Positioning equipment dealer: LSR Inc., Fort Lauderdale, Florida

The slope of the canal bank is carefully controlled to prevent erosion.

prior to placement of the expensive revetment system. Later a surveyor will come out here and do the final as-built cross-sections."

Scott Ryder, project administrator for C3TS, the DOT's construction manager, appreciates that the Leica grade control system helps expedite the project. "Time is always of the essence, and the system helps us get the finished road back in service as soon as possible, which minimizes inconvenience to the traveling public," he says.

Ryder continues, "The grade control system allows us to meet the time and money goals that are so important in this economy. Plus, the whole project is the first green project in this district. The greater efficiency of the two excavators will reduce carbon emissions by burning less fuel. We look at the contractor as our partner and will continue to work together to deliver a high-quality project."

After the slope is excavated according to the design, an excavator will place a layer of 2- to 3-inch-size crushed rock on it. The thickness of the layer ranges from 3 inches to 4 feet, depending on the design and the existing conditions. "Below water we use crushed rock, and above water we fill with sandy soil," Hackett says. Again, the PowerDigger Pro system determines the grades of the imported rock fill—thereby reducing the waste factor in the unseen slope underwater.

Cuts and fills vary. In one 1,000-foot section of embankment, Ocean Breeze may excavate 800 cubic yards and fill with 200 tons of rock. In another 1,000-foot section, the design may only call for 200 cubic yards of excavation, but 600 tons of rock fill. Unsuitable excavated soil is hauled to a stockpile for use later by the local sugar cane farmers. (The terrain is flat, and many thousands of acres of sugar cane are grown in the area.)

Following the placement of crushed rock, the contractor makes a shallow notched excavation in the middle of the slope, from +12 feet down to +8 feet of elevation, to straddle the maintained water elevation (which rises and falls). Next a non-woven geotextile filter fabric is placed over the entire slope—over the coarse stone, the notched excavation and the upper slope of soil.

Another layer of crushed stone, 1 to 2 inches in size, goes down over the filter fabric in the area of the notched excavation. That drainage layer relieves the hydrostatic pressure in the subgrade and retains the soil in the embankment, Hackett says.

After that, Ocean Breeze crews lay out the fabric-formed articulating block concrete revetment panels onto the slope and pump grout into it. When the fabric is filled with concrete grout, it looks like a huge mattress lying across the slope. The final step, Hackett says, is to place 2- to 3-inch stone at the toe of the slope and at the beginning and ending sides of the revetment for additional scour protection.

Redesigned Project

Originally the project was designed to control erosion with a turf-reinforced mat, which Hackett said is difficult to use underwater because it is buoyant and tends to float on the water surface. With Hackett's help, engineering firm Soil Reinforcement Design Inc. of Woodstock, Georgia, redesigned the project to call for the fabric-formed articulating block concrete revetment, a proven method of erosion control.

"To go from a turf-reinforced mat to the articulating concrete revetment was a win-win for the state and for the South Florida Water Management District," Ryder says. "The overall quality will be better and the long-term costs will be reduced. Plus, when the slopes stay in good shape, the road holds up better and the overall ride quality stays high."

When the erosion control system is complete, the shoulder will be widened by 3 to 5 feet and new guardrail will be placed. The existing asphalt pavement will be recycled by a hot-in-place recycling method. Three heaters will heat the pavement, which will then be milled up, rejuvenated and paved back down again. "We'll take up two inches and put two inches back down, reducing carbon emissions the whole time," Ryder says. Construction began last June, and is scheduled for completion by October 2010. SP

Daniel C. Brown is the owner of TechniComm, a communications business located in Des Plaines, Illinois.