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horsepower motors over 13 parallel-hardened steel rails. The system's total weight would be 18.9 million pounds.

Unisystems, already on board to design the stadium's retractable roof, and Walter P. Moore Engineers were selected to handle the mechanical and structural components of the tray respectively. CMX would design a natural grass turf system to fit inside.

Once we knew the parameters, we began our design work. While we were aware of other fields where the use of natural grass was adapted for covered stadiums, such as the small movable pallets at Reliant Stadium in Houston, we would be building a one-piece movable field in a single, very large container.

This created some unique challenges, including: What would be its rootzone medium? What type of grass would be best suited to the stadium and the wear and tear associated with NFL games? How would we irrigate the grass in a shallow, confined tray, both inside and outside the stadium? How would we create a drainage system workable both in the stadium on game day and in the field's stored position?

Testing

The project team agreed the next logical step in the design process would be to conduct an in-depth turf experiment. In May 2004, CMX oversaw the construction of two mockup field sections for testing and evaluation at the Cardinals' training facility. The mockups replicated, as nearly as possible, the anticipated field conditions at Cardinals Stadium. Their dimensions, 22 feet, 9 inches in length by 9 feet, 9 inches in width, represented two of the approximately 410 rectangular structural sections that would make up the overall stadium field. They were even sloped identically to the new field's slope.

Inside the mockups, there were eight sections that tested different combinations of natural grass systems including: (1) three types of root zone mix; (2) two types of grass, Tifway 419 and Celebration (each in sodded and sprigged applications); and (3) two types of drainage systems.

The testing also provided Tim Peterson, the Cardinals' talented turf manager, an opportunity to conduct a variety of moisture studies including the water retention capabilities of the various turfs. The data also is helping Tim as he maintains the new stadium's field in addition to his oversight of the teams' three grass practice fields.

The three root zone mixes tested were: (1) a USGA-specification sand stabilized with five pounds of polyurethene fibers and five pounds of polypropylene fibers per ton of growing media; (2) a blend of 80% USGA-specification sand with 10% Axis synthetic beads and 10%


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"Worm Gold" organic material; and (3) USGA-specification sand with no additional amendments.

During the experiment, we periodically cut 12-inch square sections in the turf to measure root growth and observe the drainage system. We also conducted Clegg Impact Tests on both the mock-up fields and the adjacent practice fields to determine the general firmness of the various mixes as well as a variety of tests to measure moisture content and retention.

While each of the root mixes performed well, option #1 with its sand and stabilizer fibers proved to be the best. It most nearly matched the impact density of the existing practice fields and was the most effective at retaining moisture for root growth.

For the actual grass, the evaluation team chose Tifway 419. It was thick, green, and firm with a soft texture and deep root growth, and demonstrated superior ability to regenerate after divot damage.

Finally, although there was little visible difference in surface quality between the stolon and sod areas, the test sections planted with stolons provided stronger root growth. We therefore recommended a turf established with stolons, assuming a sufficient growing season in the spring and summer leading up to the stadium's opening.

In addition to demonstrating better root growth, we felt a grass field established with stolons would have less initial thatch, eliminate the chance of introducing a soil barrier layer between the sod and sand root-zone, and provide cost savings. If a sufficient growing season was not possible, sod could be used as an alternative.

For the underlying drainage mat, we selected the "Draincore 2" system by Airfield Systems, which was extremely efficient in collecting and discharging excess water and also provided excellent moisture control.

Installation

In mid-March of this year, the long-awaited installation began. First came the laying of a non-permeable plastic liner to provide a water-tight barrier and protect the structural steel in the tray from rusting.

Next was the placement of two one-inch layers of the drainage mat covered with a woven geotextile fabric, a permeable product that allows water to pass through into the drainage mat while holding sand from the rootzone mix in place. Then, the irrigation system, using a low-profile fitting configuration and Hunter "Ultra" sport sprinkler heads, was laid on top of the drainage mats.

The next step, in late April, was filling the mammoth tray with nearly five million tons of the sand and stabilizing fiber mix. The sand and fibers were mixed offsite and brought in by truck, unloaded and then scooped up by a front-end loader. The mixture was then placed on a long conveyor belt and spread uniformly across the tray.

In early May (and on schedule) the sprigging process began. The stolons used were derived from Tifway 419 sod, grown over 18 months in a medium consisting of a mixture of sand, clay and silt at the Evergreen Turf sod farm in southern Arizona. Installation of the stolons occurred within 12 hours of their harvest.

The sprigging, under the supervision of Valley Crest Contracting, was accomplished using a "hydro cannon" equipped with a fire hydrant-type hose shooting the stolons onto the sand base at a rate of 20 bushels per 1000 square feet.

The stolons were sliced and rolled into the surface by a lightweight disc machine and syringed to prevent drying and to bind them to the rootzone. Wood fiber mulch was added to the surface at a rate of 45 pounds per 1000 square feet.

It was time to water (and water and water) the field and watch the grass grow.

By late May, the grass was beginning to green. By mid-June, it was fully on its way to becoming an established field, and was given its first 740-foot test drive into the stadium, with eight more weeks of growing time before the Cardinals' first game.

We used that time to help in the fine-tuning of the field including fertilizing, rolling and topdressing, and working with the Cardinals to provide a field that will be durable and easy to maintain throughout 2006 and many seasons to come.

This has been CMX's most visible project because the field will be on national display for a Cardinals' Monday night game, the Tostitos Fiesta Bowl, and next year, when Cardinals Stadium will host Super Bowl XLII.

Mike Lloyd, PE, with more than 30 years of experience in the development of sports projects, is President of CMX Sports Engineers. ■

Can you identify this sports turf problem?

Problem: Brown circles on turf
Turfgrass Area: Athletic field
Location: Iowa
Grass Variety: Ryegrass/bluegrass blend

Answer to John Mascaro's Photo Quiz on Page 37

Answer to John Mascaro's Photo Quiz on Page 37

John Mascaro is President of Turf-Tec International

Newest US soccer field opens this month

The newly built Toyota Park in Chicago, the fourth major soccer-specific field in the United States, features a turf-conditioning system underground. The system was installed in November 2005 by Althoff Industries, which built a similar system during the 2003-2004 renovation of Soldier Field.

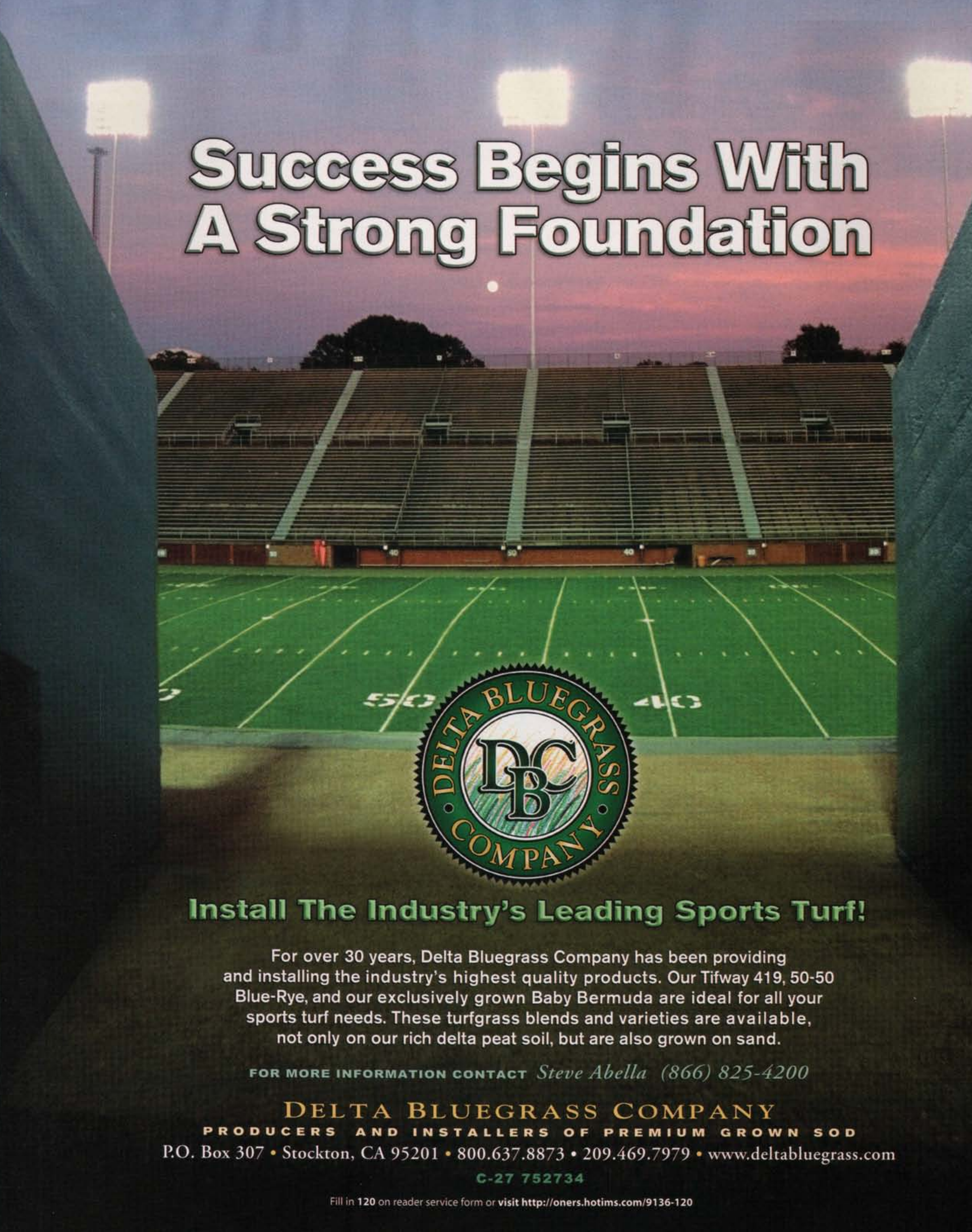
Located on the Southwest side of the city, the $70 million, 20,000-seat Toyota Park is home of the Chicago Fire, a Major League Soccer franchise whose season potentially stretches from early April to mid-November, depending upon playoff advancement. There are also plans for local high school football teams to use the field as well.

The turf-conditioning system at Toyota Park, manufactured by Uponor North America, circulates a warm, water-and-glycol mixture through underground tubing, made of crosslinked polyethylene (PEX). The intent is to warm the rootzone beneath the grass, so that the playing surface remains soft and forgiving, even at sub-freezing temperatures.

The radiant heating system consists of roughly 28 miles (over 150,000 linear feet) of 3/4-inch Uponor Wirsbo hePEX plus tubing, which serpentines from end zone to end zone, eight inches on center and 10 inches below the 200 by 425-foot playing surface. The only connections are at the copper manifolds, positioned at the south end of the field, where each PEX loop begins and ends, thus moving potential service issues to outside the playing area. The copper headers are fitted with stubouts at the factory for making the PEX connections, saving substantial time on the job site.

A pair of commercial-grade, 150-horsepower boilers, situated in a mechanical room under the concrete stands on the east side of the field, feed the 50%-glycol solution through two heat exchangers and 1,400 feet of four-inch copper supply and return piping, on their way to roughly 400 feet of manifold. Because so much of it is encased in concrete under the stands, the copper portion of the system had to be thoroughly tested at high pressures even before the PEX tubing was completely installed on the field. "We had to be sure there were absolutely no problems," says Althoff senior vice president Christopher Bennett, who supervised both this and the

Project supervisor Chris Bennett (left), senior vice president at Althoff Industries, with John Lavin, shown in early November 2005, with the partially installed turf-conditioning system at the new Toyota Park in the background.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Motorized sled, custom-made for the project by Althoff Industries, carried the loops of PEX tubing from one end of the playing field to the other.

Soldier Field projects. "Once the concrete is poured, it's pretty difficult to fix any leaks."

The glycol solution comes off the two boilers at 180 degrees F, while the use of mixing valves reduces the temperature of the solution to a maximum of 130 degrees F before pumping it into the 168 loops of underground PEX piping that transverse the field. As the outdoor temperature falls, the system automatically boosts the water temperature in the tubing to protect the turf root system.

"It is a closed, reverse-return system that is self-balancing," Bennett says. "The first half of each loop functions the supply line, moving the fluid from the copper manifold at the south end to the far north end of the field. The return line brings the solution back to that manifold, which then moves it to the boilers underneath the stands for reheating and recirculation."

Four heating zones

Like the interior of a home or a large office, the field is segmented into four heating zones, also running the length of the field from goal to goal. Each zone contains 42 PEX loops and two temperature sensors that sit within underground boxes connected to one another with plastic conduit. On sunny days, the demand for warmth varies from zone to zone, depending on the position of the sun. The sensors in each zone