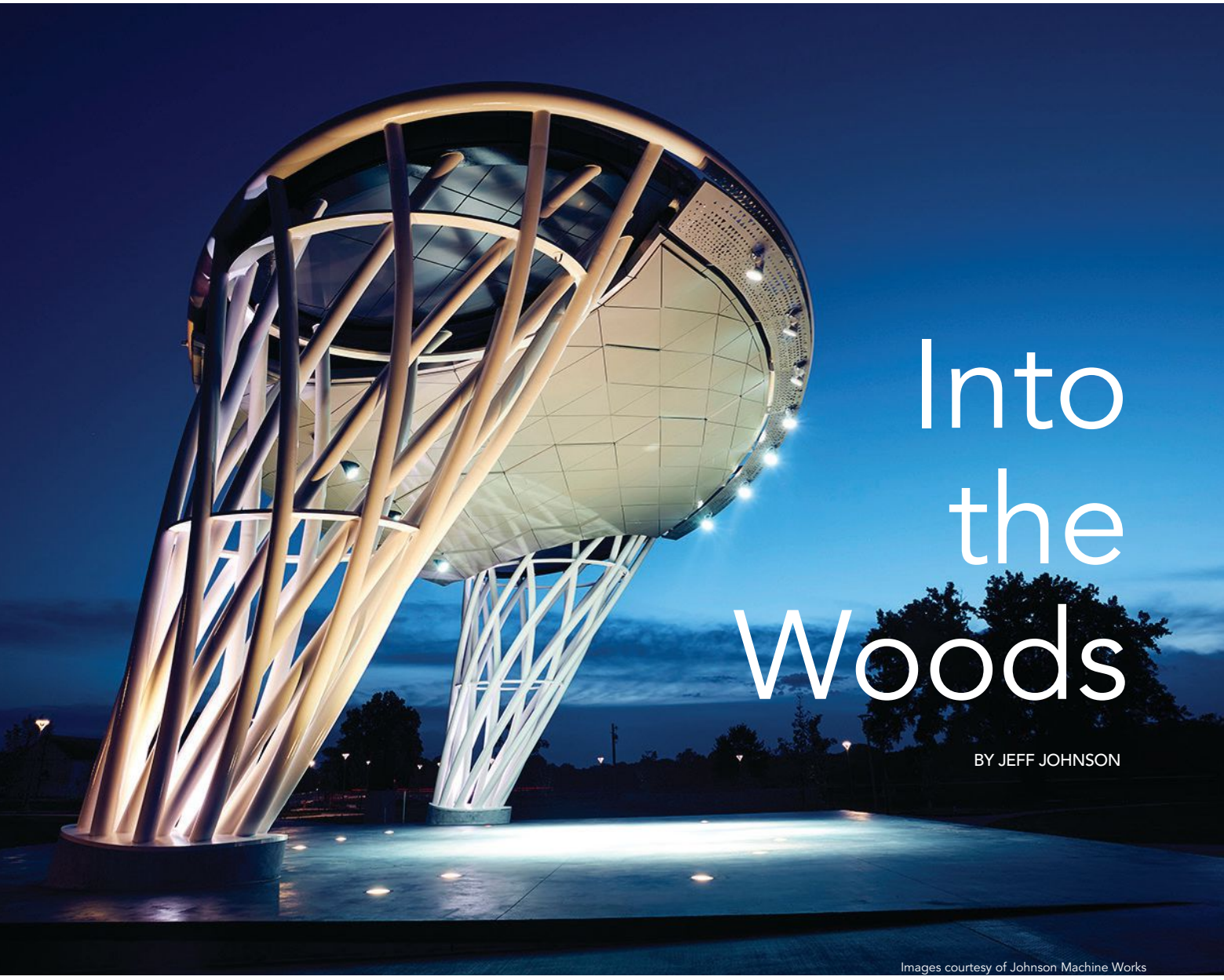
Curving steel trees frame a new outdoor performance space in Des Moines.



Into the Woods

BY JEFF JOHNSON

Images courtesy of Johnson Machine Works

Jeff Johnson (**jjohnson@jmworks.com**) is the CEO of Johnson Machine Works, Inc.

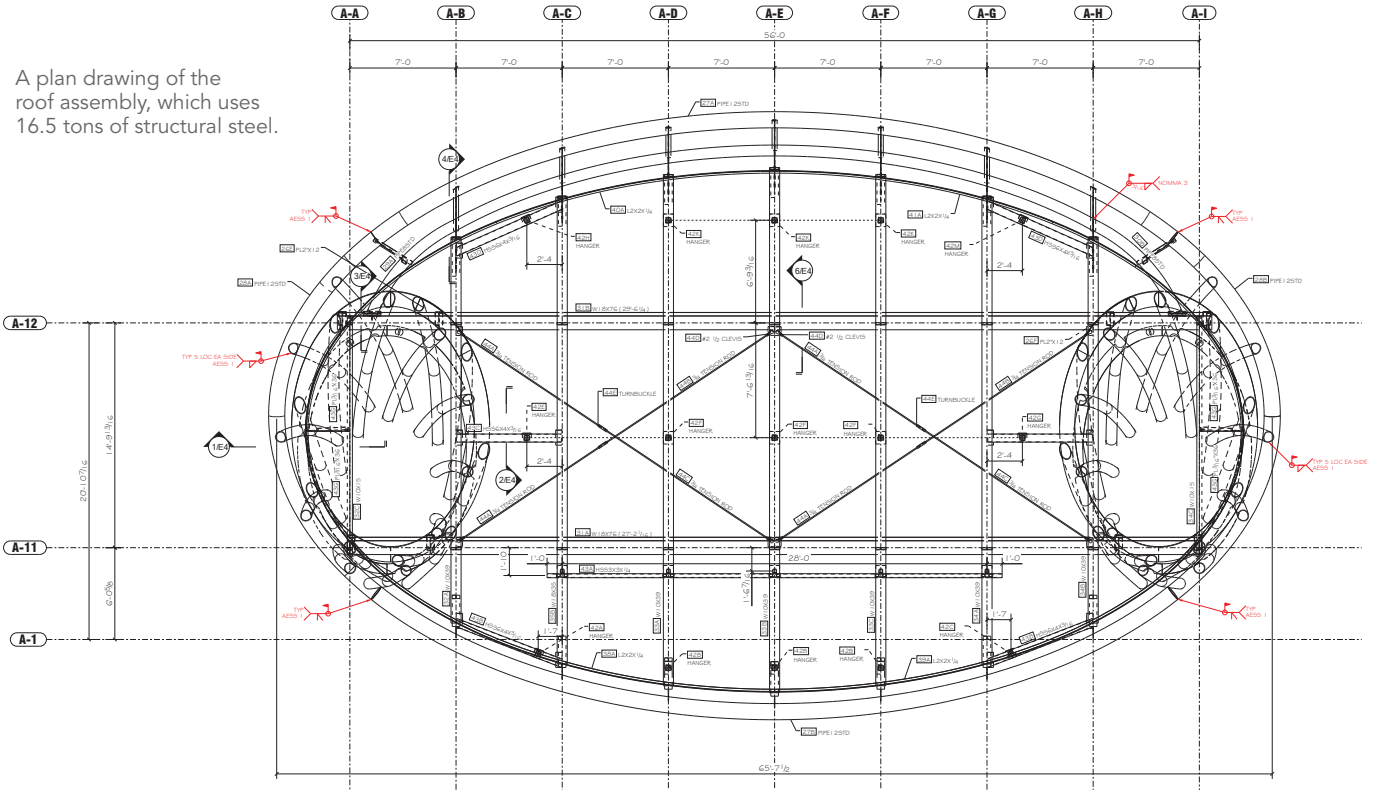
THERE IS MUSIC between the trees in Water Works Park.

Hugging the bank of Raccoon River near downtown Des Moines, the 1,500-acre riverside woodland area is one of the country's largest urban parks, an outdoor oasis in the heart of the city.

In an effort to bring more residents and visitors to the park, the Water Works Park Foundation embarked on a plan to develop an underused flood-prone space alongside a mature arboretum. The focal point is the steel-framed Lauridsen Amphitheater, an outdoor stage flanked by two woven steel "trees."

Designed by architect RDG, the complex, curved steel columns are a natural response to the local environment, inspired by the form of an oak tree. "RDG was charged to provide a flood-resilient, dual-sided amphitheater structure that would primarily stand as a folly in the park for the everyday experience, but then transform as an armature to hold equipment for

A plan drawing of the roof assembly, which uses 16.5 tons of structural steel.



musical performances ranging in size—small performances facing south and medium to large performances positioned facing north," said Tyler Jessen, lead architect with RGD. "The structure needed to take on a sculptural form that was both iconic and responding to the contextual backdrop of a wooded park."

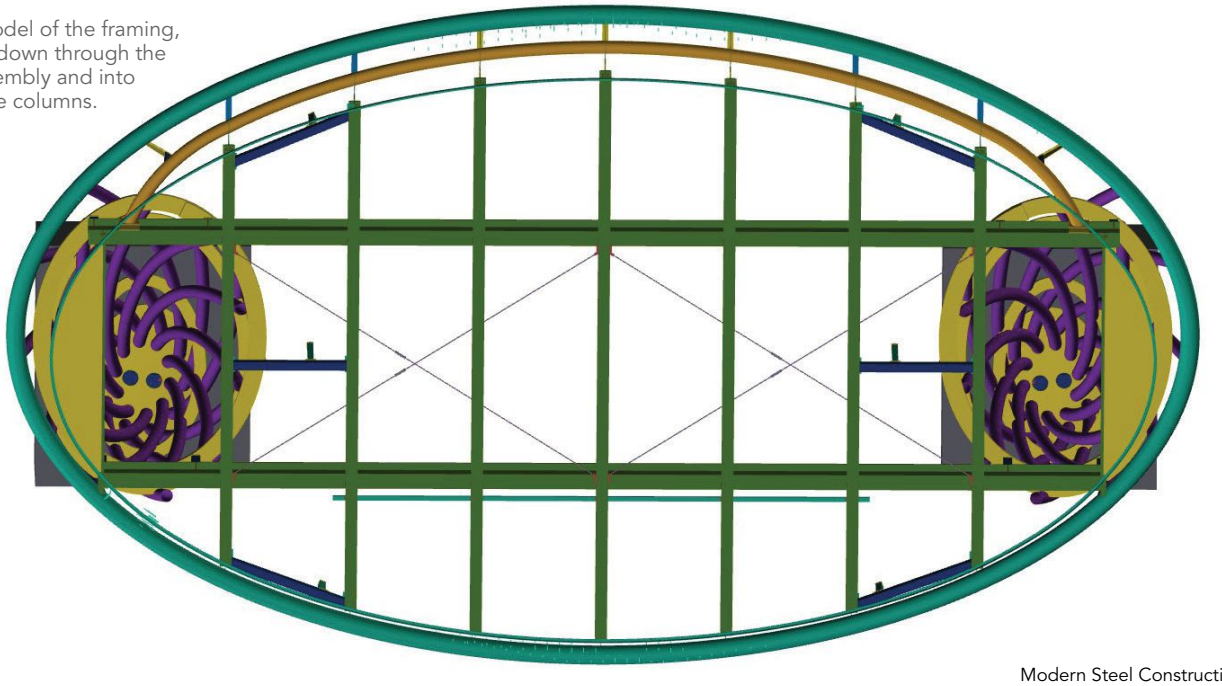
Complex Trees

The two main column assemblies, or "tree limb cloisters," are each comprised of 20 8-in.-diameter hollow structural section (HSS) columns that twist from a concrete pier base to support a canopy clad with aluminum composite material (ACM). Each column assembly weighs approximately 13.5 tons.

The canopy, in layers.

1 BLACK STANDING SEAM ROOF
2 PAINTED 12" DIA STEEL PIPE
3 CANOPY STEEL FRAMING
4 ALUMINUM COMPOSITE CANOPY
5 PAINTED STEEL COLUMN
6 CAST-IN-PLACE CONCRETE BASE
7 LED COLOR CHANGING LIGHTS

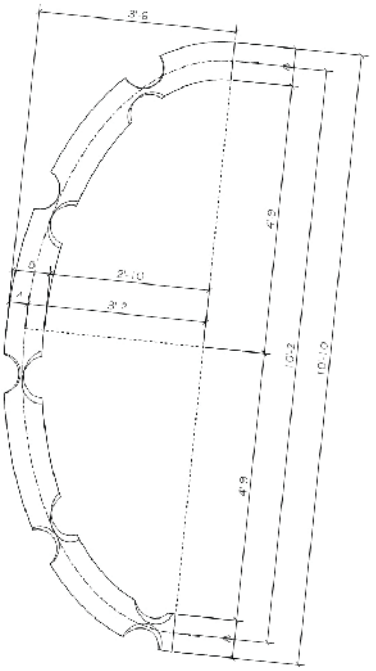
A 3D model of the framing, looking down through the roof assembly and into both tree columns.



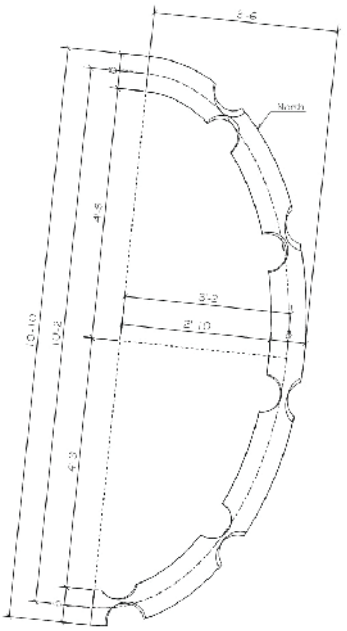
above and right: The complex, curved steel column assemblies are a natural response to the local environment, inspired by the form of an oak tree. Each weighs 13.5 tons.

"The helical, canted nature of the columns presented unique challenges for the engineering model," explained Justin Dahlberg with the project's structural engineer, Saul Engineering (now KPFF). "Base connections with overturning moments necessitated an adequate amount of steel but without compromising the design aesthetic."

As the steel fabricator, Johnson Machine Works (JMW) coordinated with general contractor Henkel Construction to fabricate and erect the large rolled shapes to achieve the tight tolerances of the round HSS, which were designated as architecturally exposed structural steel (AESS)—specifically, AESS Category 1—from the bottom of the assembly up to the bottom side of the lower ring, which is just under 13 ft above the stage floor. (Category 1 is the minimum treatment of



1 ~ PLATE RING ~ 24A



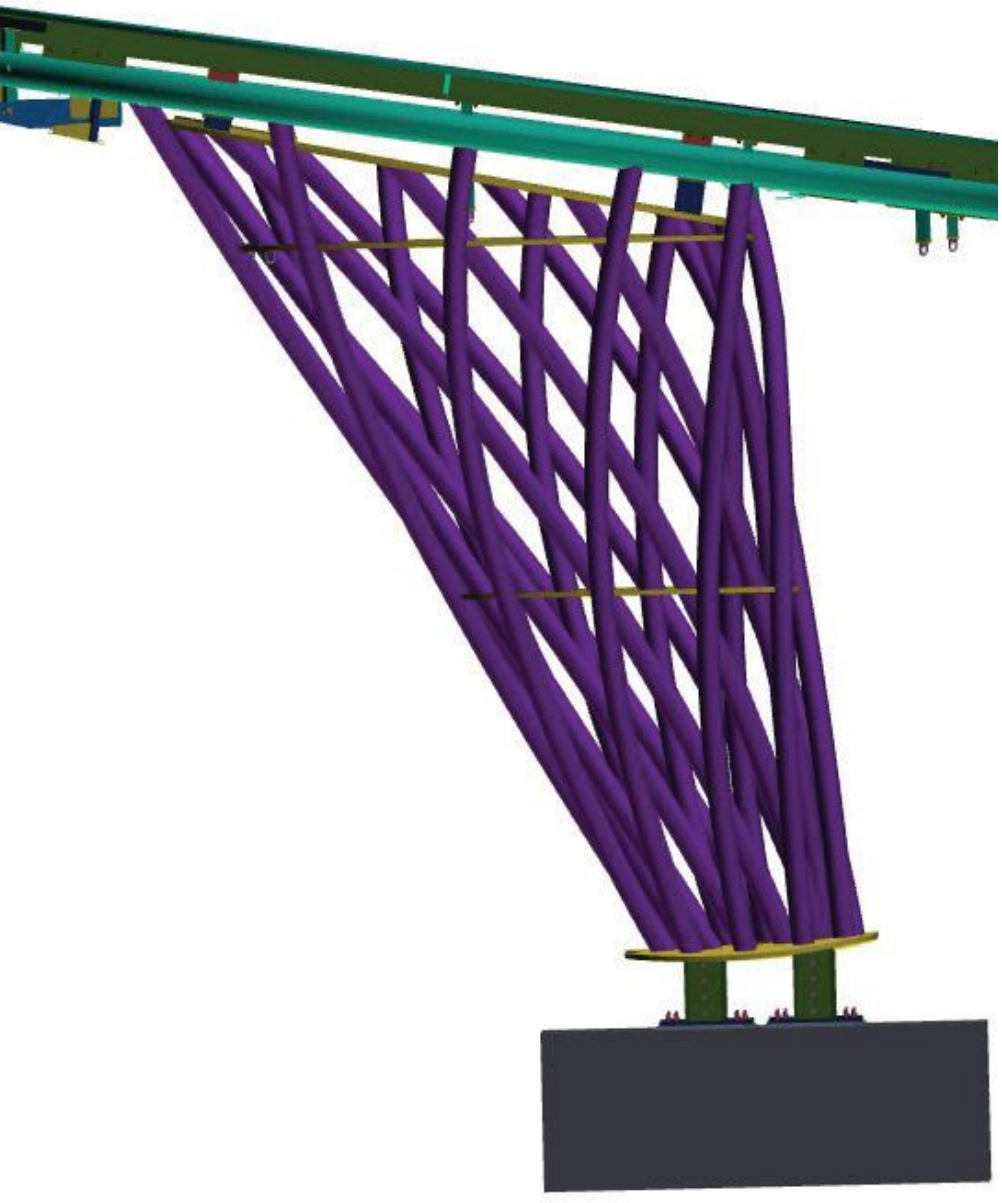
1 ~ PLATE RING ~ 24B

exposed steel beyond standard fabrication of structural steel. (For more on the various AISC AESS levels, see "Maximum Exposure" in the November 2017 issue, available at www.modernsteel.com.) JMW applied a PPG Coraflon ADS zinc-rich epoxy primer to the steel in the shop, and Coraflon ADS Epoxy Intermediate Primer and Coraflon ADS Intermix coats were applied in the field.

The spiral columns are held together with rings at three locations. The rings are 2-in.-thick plate, each made from two pieces.

right: The column assemblies being fit up in Johnson Machine Works' shop.

below: Each row was offset to allow the HSS—curved by bender-roller Chicago Metal Rolled Products—to spiral in opposite directions while bypassing each other without intersecting each other.



The 20 HSS columns of each tree are divided into two oval circles of ten, one inside the other, with no two columns being exactly the same. Each row was offset to allow these sections—curved by bender-roller Chicago Metal Rolled Products (CMRP)—to spiral in opposite directions while bypassing each other without intersecting each other. Each column was detailed in three sections, all with their own radius and rotation point.

The spiral columns are held together with rings at three locations. The rings are 2-in.-thick plate, each made from two pieces. JMW created these rings from flat plates that were notched in order to perfectly match the gentle transition of the inner and outer HSS as they rise and cant from their more compact base. Upon receiving the curved sections from CMRP, JMW welded them to their respective baseplate and steel rings. The 2-in. baseplates have two W-shape "stools" welded to them such that the baseplate sits on anchor bolts—1¼ in. in diameter and 1 ft, 10 in. long. The baseplates also have several anchor plates with rebar running through them, and rebar also runs through the webs of the stools. The stools and rebar were cast in concrete from the bottom of the 2-in. plate to the footing.

Topping the two woven tree column assemblies is a canopy roof structure weighing approximately 16.5 tons, comprised of W18×76, W18×35, and W10×39 beams and tension rods. In addition, 12-in. and 8-in. round HSS create another ring around the roof structure as an architectural feature.

above: Transporting the bottom half of one of the tree column assemblies to the site.

below: The bottom portions of the assemblies were fabricated to AESS Category 1 requirements.

Growing Together

JMW and KPFF worked together on multiple design changes to facilitate smoother fabrication and installation, including altering the anchor scheme. Originally, the 2-in. baseplates were to have precast concrete section under them, with the HSS columns field-welded to the plate. But thanks to assembling the column trees and plate in the shop, field welding was avoided. The 2-in. plate rings were also a design change suggested by JMW. The rings were originally designed to be HSS with "knuckle plate" connections at each location where an HSS column penetrated a ring. The plate scheme drastically reduced the amount of fabrication and welding required for each ring and allowed for a two-component ring instead of a multiple-component HSS and bent-plate ring.

Jason Knipp, project manager with Henkel Construction, managed weather delays and job site challenges to pull the entire project together. Due it its location on a floodplain, the job site was underwater a couple times and a lot of soil was washed away at one point—though luckily the stage site itself was never underwater. Knipp also worked with JMW to modify the precast foundation to cast-in-place in order to provide a more economical and efficient foundation for the amphitheater. The coordination between the two companies also led to other enhancements regarding constructability. For example, the columns were fully erected in JMW's fabrication facility, as was the entire roof structure. Thanks to this extensive preassembly work, erection in the field was smooth and without delay. The erection team was able to unload

Due it its location on a floodplain, the job site was underwater a couple times during construction, and a lot of soil was washed away at one point—though luckily the stage site itself was never underwater.

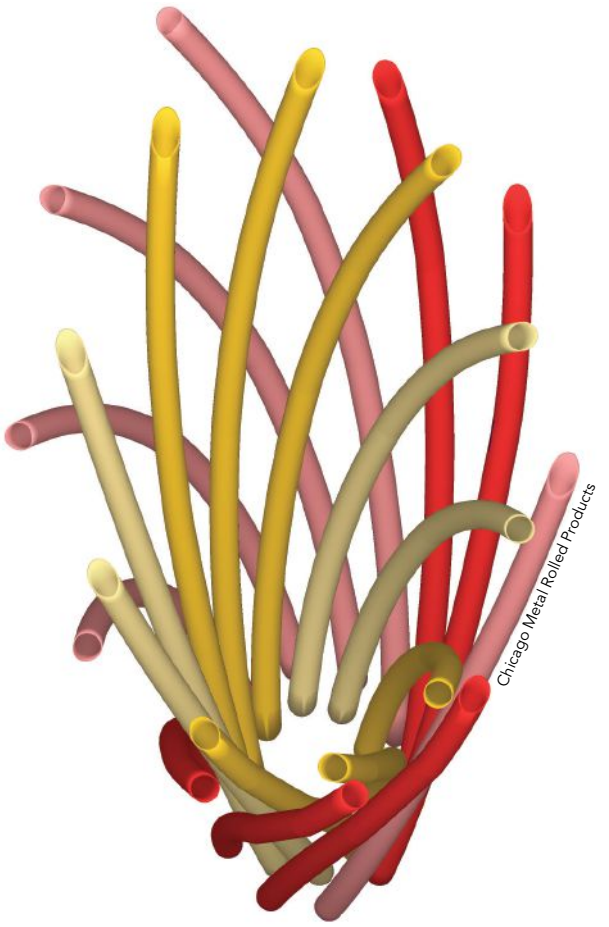
All the Right Angles

Curving one member is difficult. Curving 20 members that rotate in proximity to one another—half of them twisting one way and the others spiraling in the opposite direction—presents a whole other level of complexity.

When presented with drawings from Johnson Machine Works, our first order of business was to obtain a full-scale model of the amphitheater to determine proper radii for twisted columns and pipe segments, then create our own in-house 3D models to generate shop instructions. Each of the 20 lengths of 8.625×0.325 HSS that form one woven column was unique; no two were of the exact same geometry. Luckily, the 20 HSS forming the second column assembly were a mirror image of the ones forming first column assembly.

Once we generated our 3D model, we were able to extract data for all 40 twisted HSS columns to draw 40 unique 2D templates used for checking each column after it was rolled. These templates allowed our experienced bending machine operator to mark a column and position it onto the template in such a way that all data points required to pass inspection were hit. We completed this complex project of rolled elliptical segments without having to turn *any* material into scrap metal.

—Laurel P. Chavez,
Project Manager and CAD Engineer,
Chicago Metal Rolled Products



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the column assemblies from the truck and set them right in place—again, with no field welding required. The roof was also shop-assembled and delivered in three sections, also facilitating simpler erection.

Since opening to the public in the summer of 2019, the amphitheater has already hosted several concerts and civic events. Jessen's hope was to have visitor's initial reaction to the structure be one of awe and wonder when approached from all angles. Through the purposeful partnership between architect, engineer, contractor, and fabricator, the structure indeed inspires awe and wonder, creating a stage that is more than just a stage, that blends in beautifully and becomes one with its natural surroundings. ■

Owner
Water Works Park Foundation, Des Moines

General Contractor
Henkel Construction, Ames, Iowa

Architect
RDG Planning and Design, Des Moines

Structural Engineer
KPFF (formerly Saul Engineering), Des Moines

Steel Team

Fabricator and Detailer
Johnson Machine Works, Inc., Chariton, Iowa

Erector
Northwest Steel Erection, Inc., Grimes, Iowa

Bender-Roller
Chicago Metal Rolled Products, Chicago