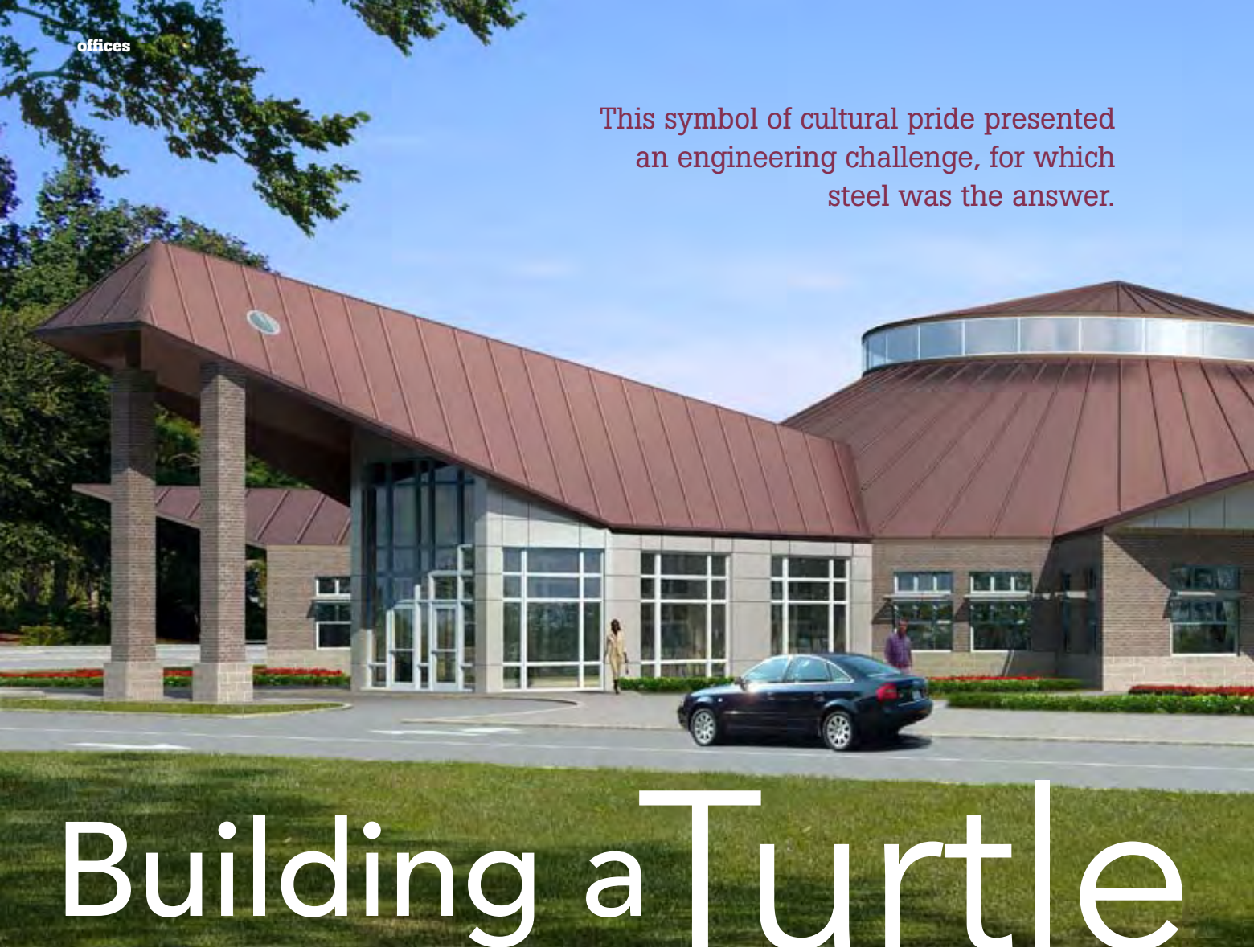


This symbol of cultural pride presented an engineering challenge, for which steel was the answer.

Building a Turtle

BY CEVYN MEYER, P.E.

WHEN MEMBERS OF THE LUMBEE TRIBE in Pembroke, N.C., decided to build a badly needed office complex, they wanted a structure that also would help preserve their culture. Tribal leaders initially suggested an oval-shaped building to resemble a turtle, the Native American symbol of power, strength and longevity. Then architects from Native American Design Services took it a step further, designing a building that would actually be shaped like a turtle.

Then came the hard part.

Plans called for the Housing Complex to have two concentric circles with a steep slope from the inner circle—the center of the shell—to the outer one, which is the base. The engineers called joist manufacturer Vulcraft for advice.

"It seemed pretty complex at the start," said John Kells, a project manager who was with Tower Engineering Professionals at the time. "Vulcraft came back to us quickly with a proposed design. Once we saw what they could do, it was an easy decision."

Vulcraft design engineer Henry Tennent, P.E., suggested a girder for the inner circle with a 63-ft span. On top of the span, he recommended a series of sloped joists that would be positioned every 15°, spanning from the center of the girder out to the edge of the inner circle. The joists would slope down to form the top of the shell.

Tennent noticed, though, that if he positioned a joist every 15°, at the edge of the outer circle they would be too far apart for the deck to span. On the other hand, if he used closer spacing on the low end, crews wouldn't be able to fit all the bearing seats at the high end without them interfering with each other.

He suggested forming a third circle at an elevation halfway between the top and the edge, using half-length joists and spanning them back to a header. The result is that by the time you get to the outside of the lower circle, the joists spacing has gone to 7.5° apart.

"There's a long joist that goes from the center to the edges, and then a short joist that goes from the edge halfway back to the center," Tennent says. "The series of headers forms a circle at the half point."

Tennent says he often partners with engineers, but projects this complex are rare.

"We can do some spectacular things with joists," he says. "It's exciting when you get a project like this and you're working closely with the engineers, and you're telling them things that surprise them, and they're telling you things that surprise you."

Once the design was approved, Goldsboro, N.C.-based Griffin Steel & Supply purchased about 30 tons of joist and 40,000 sq. ft of deck from Vulcraft. At one point, when a change was needed, Vulcraft redid the drawings and had them back in production

Native American Design Services

Built to consolidate four separate office locations into one, the Lumbee Tribal Housing Complex is designed to resemble a turtle, a Native American symbol of power, strength and longevity.

within two weeks. "That's phenomenal," says Griffin Steel president Greg Nichols.

Advice for Similar Projects

One thing to keep in mind when designing projects with steeply sloping joists, Tennent says, is to make sure there's adequate seat depth at the high end. Without that, you risk fouling problems with the end web of the joist.

"Joists with steeper slopes require deeper seats," Tennent says.

Also, because you need a bearing point at the center of the dome, you have two choices: Place a column up through the center. Or do what the crews did for the turtle-shaped building, and place a girder through the center of the circle to support the joists going around it.

The girder through the center of the circle gives people more open space once they're using the building, of course. But there are also other factors to consider.

"It would really depend on the size of the building," Tennent says. "If the length of the girder results in it being too deep or too heavy, it might be cheaper to do a column. There was a lot of weight we had to support at the center of the circle, but it wasn't excessive."

Kells, the project manager, says one of the challenges was getting the pitches correct at the head of the turtle, because there were so many angles coming in horizontally and vertically. The beam lengths on the

Above: Steeply sloped open web steel joists require a much greater seat depth, at the high end, than those placed more nearly horizontal.

Above: Placement of steel decking to form the roof of the office complex followed quickly after the sloping joists were put in place.

Cevyn Meyer, P.E., is the engineering manager for Nucor Vulcraft Group in Florence, S.C., and has worked with the company for more than 24 years. He is a director and past president of the Steel Deck Institute and has served on various advisory committees for AISC, SEAA, NEA and SJI.

Below: Half-length joists on the lower portion of the slope between the full-length joists reduce the maximum metal decking span. The upper ends of the half-length joists are supported by an intermediate header.

photos by NUCOR/Vulcraft Group, Florence, S.C.

steel shop drawings were measured down to 1/16 of an inch, so it would all fit together.

"It was impressive," Kells says.

A thorough review of the shop drawings also helped save time and money, Kells said, because he noticed the placement of some anchor bolts needed to be adjusted. The anchor bolts carry most of the wind resistance in a structure with such an open floor plan, and it would have been a difficult problem to fix once they were fastened to concrete.

"If you double- and triple-check on paper, it alleviates problems out in the field," Kells says. "With a project this complex, it was extremely important that we had open lines of communication with the contractor and the fabricator."

'Talk of the Town'

Crews have completed much of the building's frame, and tribal leaders began moving into the facility in December. When the move is complete, the building will combine services now housed in four locations, ending a system many tribal members found confusing and frustrating. At the center of the structure, because of its turtle-shape, there also will be a high ceiling ringed by windows where the Tribal Council will hold its meetings. "It's a grand space—very impressive," says Che' Clark, lead designer for Native American Design Services.

Tribal leaders are excited that they will be able to better serve their members. They also know the building will serve as a landmark for future generations.

MetCon Construction

Above: A built-up platform at the center of a 63-ft girder truss provides the upper support for the steel joists supporting the roof.

Opposite page: The girder truss was built out from both sides of this weldment, which was inverted to form the center support for the upper ring of steel joists.

"It's already the talk of the town," said Alex Baker, the Lumbee Tribe's public information manager. "This is something that is going to instill a lot of pride in our community and in our heritage."

MSC

Architect
Native American Design Services, Pembroke, N.C.

Structural Engineer
Tower Engineering Professionals, Raleigh, N.C.

General Contractor
MetCon Construction, Pembroke, N.C.

Steel Fabricator
Griffin Steel & Supply, Goldsboro, N.C. (AISC Member)

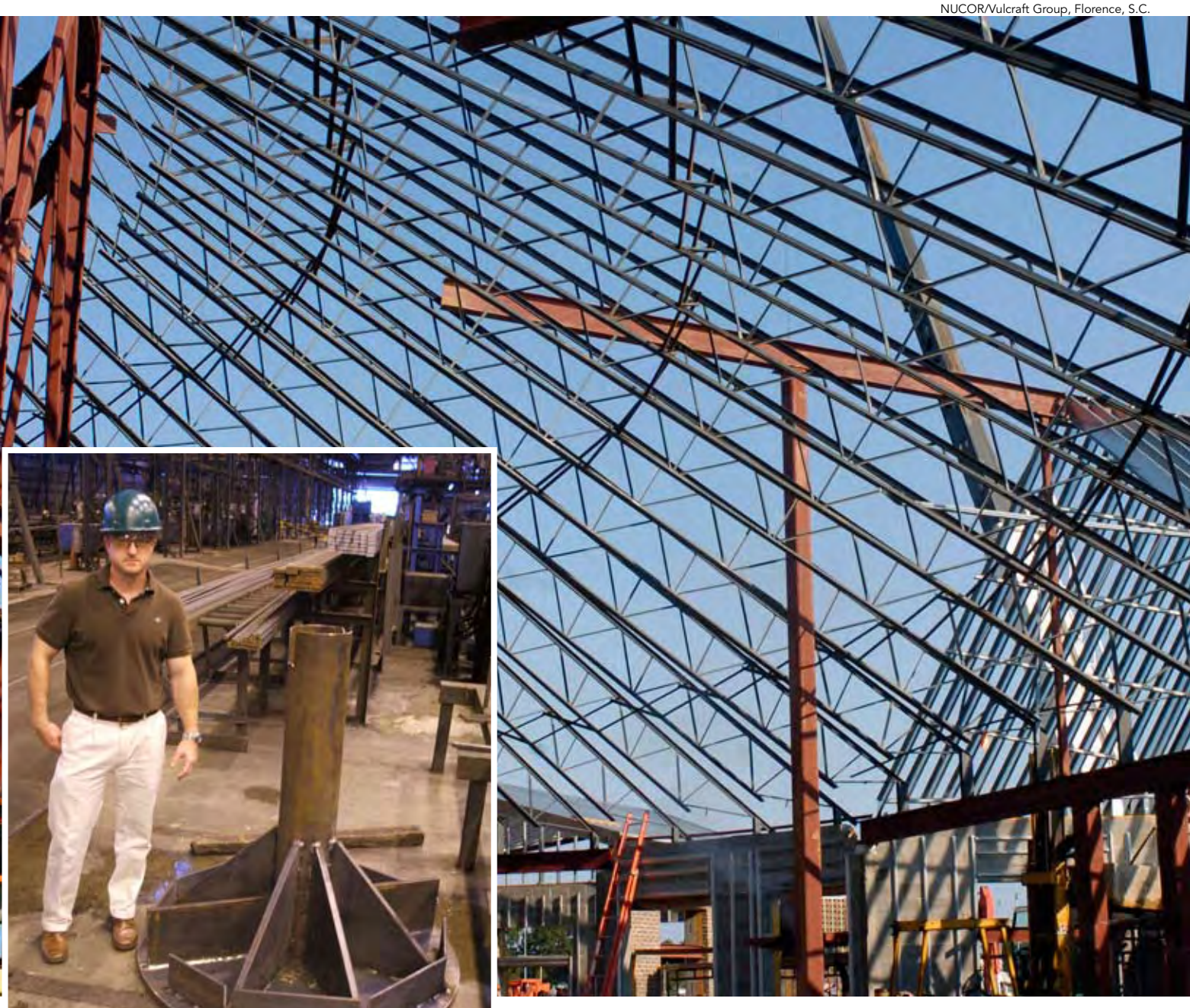
Steel Detailing
Nucor Vulcraft Group, Florence, S.C. (AISC Member)
Queen Engineering & Design, Raleigh, N.C. (AISC Member)

Joist/Deck Supplier
Nucor Vulcraft Group, Florence, S.C. (AISC Member)

Structural Design Software
Risa-3D

Steel Drawings Software
AutoCAD 2008

NUCOR/Vulcraft Group, Florence, S.C.



NUCOR/Vulcraft Group, Florence, S.C.

Lower joists form the oval shape that ultimately will produce the desired turtle appearance.