



Project Summary

Organization:

JDI Group

Solution:

Structural Engineering

Location:

Toledo, Ohio

Project Objective:

- Engineer structural elements of man-made shade tree to meet complex load requirements
- Design tubular steel members to withstand flexure, compression, and torsion
- Retain architect's vision for aesthetic appearance of tree trunk, branches, and leaves

Products used:

RAM Elements

Fast Facts

- 40-foot man-made tree designed to withstand ramming by 14,000-pound elephant
- Elephant loads calculated based on animal height, weight, speed, and behavior
- RAM Elements allowed designers to redistribute loads by tweaking size of tree limbs

ROI

- JDI saved numerous design hours using RAM Elements for quick and efficient analysis
- Precision yielded high comfort level with structure's ability to withstand loading conditions
- Resizing members to redistribute loads led to aesthetic yet economical design
- Sturdy steel trees provide long-lasting shade for elephants

JDI Group's Analysis Ensures Zoo Exhibit Withstands Highly Unusual Force

Designed Using RAM Elements, Man-Made Tree Can Absorb Impact of an Elephant Ramming His Head

Elephants Are Not Covered in ASCE 7

The Portico Group, Seattle, Wash., the lead architect on the Toledo (Ohio) Zoo Elephant Exhibit Renovation Project, contracted with the JDI Group of Holland, Ohio, to engineer the structural elements for an elephant shade structure. The man-made tree not only had to withstand wind forces and snow loading, but also the impact of a full-grown bull elephant ramming the trunk. Bentley's RAM Elements was the software of choice to handle these complex and unusual load calculations quickly and easily.

JDI's structural engineers might have posed the question this way: If an angry 14,000-pound elephant rammed his head against a 40-foot artificial tree, how much force would he exert on the structure? Of the 98 loading combinations analyzed during the design of shade structures for the Toledo Zoo elephant exhibit, that particular criteria was not found in the ASCE 7 Standard for Minimum Design Loads for Buildings and Other Structures.

"RAM Elements gave us a very economical design. For some of the members, we had to skinny down the dimensions to meet the architect's requirements. Using the software, we could tweak the design very efficiently."

— Frederick Quinn, senior project manager, JDI Group, Inc.

"We analyzed many combinations of wind loads and wind in combination with snow loads, as well as seismic loading," said Frederick Quinn, senior project manager at the JDI Group. "We had one load case—elephants—not covered in ASCE 7. We came up with scenarios for the behavior of the elephants by working with the zoo and their team of experts familiar with elephants."

The man-made shade structures are part of a \$14 million expansion of the zoo's elephant display designed by the Portico Group. The structures were a practical alternative to live trees, which elephants quickly destroy by digging around the base, eating the roots, and stripping the bark. The sturdy steel structures, constructed entirely of weathering steel, have tubular steel branches covered with netting to simulate leaves. The structures also support hoists suspended from the branches to dangle hay-stuffed barrels and other enrichment devices. Zookeepers can raise and lower the hoists and swap out various entertaining contraptions to keep the elephants occupied.



This is a top view rendering of the shade structure. The hoists that raise and lower the enrichment devices can be seen in this view.

The shade structures are designed to withstand elephants leaning on them, rubbing against them, pushing on them with their forefeet, and head-butting them from a running start. The branches are high enough to be out of reach of the largest elephant, which may well be Louie, a seven-year-old youngster expected to be one of the biggest elephants on record at the zoo. When he is full grown, Louie should be able to reach nearly 30 feet high when he stands on his hind legs.

RAM Elements made it very efficient and easy to do, and it was quick.

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Members Subject to Complex Forces

To perform the structural analysis, JDI imported Portico's AutoCAD 3D geometry into RAM Elements. RAM Elements provides quick, reliable tools for specific structural tasks. It is the only structural engineering software system that offers finite element analysis plus stand-alone or integrated design tools all in one low-cost, easy-to-use package.

"It worked very efficiently," Quinn noted. "We were able to bring all the node points and the total 3D configuration into RAM Elements, add the loading criteria and member sizes, and create the load combinations." The analysis was complex because of the angled branches and numerous cantilevers and projections, and the structural elements were subject to flexure, compression, and torsion.

Load criteria for elements such as wind and snow were fairly straightforward. Elephant loads were deduced with the help of zoo management, which advised on such criteria as animal weight and the speed at which they can move. "We had to consider a potentially angry elephant," Quinn said. "They are very intelligent animals, and the likelihood of ramming their heads into the structure is low, but we had to consider that possibility. How fast would he be moving and what load would he impart when he rammed it? That factored into the calculations."

After adjusting the structural supports to withstand even an angry elephant, the final design was still in line with the aesthetically proportioned artificial shade tree envisioned by Portico. It was the size of the branch-like members that required some adjustment to support the simulated leaf fabric under snow and wind loads. "Aesthetics played a factor. The architects wanted it to look a certain way, so we played around with the member sizes quite a bit," Quinn said. Even so, the framing ended up slightly larger than anticipated, but still within budget.

Quinn explained: "RAM Elements gave us a very economical design. For some of the members, we had to skinny down

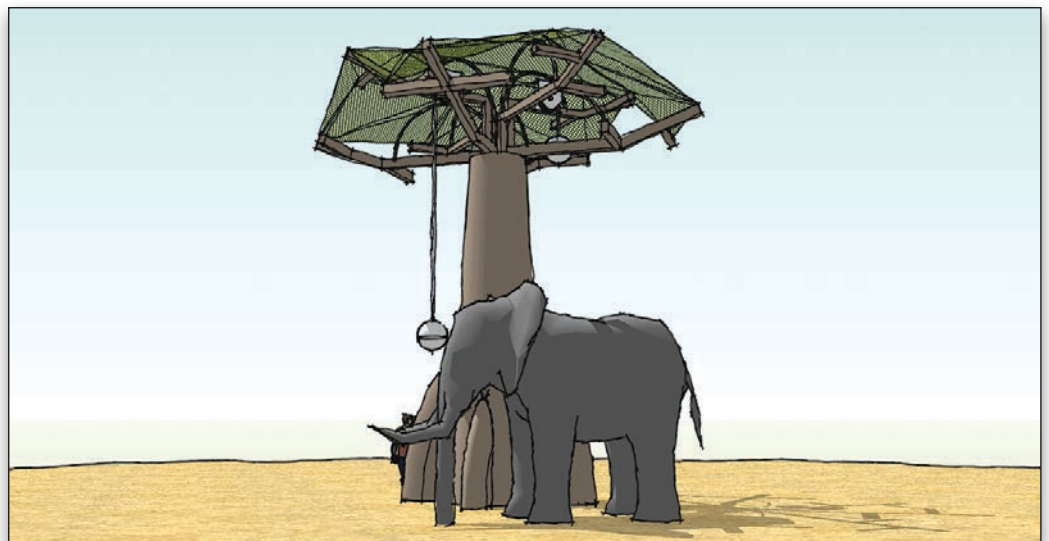


This is a rendering of one of the shade structures as seen by visitors.

the dimensions to meet the architect's requirements. Using the software, we could tweak the design very efficiently. We could increase other member sizes to redistribute the load, and take the load off certain elements to get the sizes down. RAM Elements made it very efficient and easy to do, and it was quick. You could run the analyses in a short period of time. If you had to do it by hand, it would have been a nearly impossible task."

Two structures are now shading elephants in their expanded digs, completed in early 2010. Two more structures will shade the cow pen, which started construction in late 2010. A fifth, more petite structure will shade the rhino exhibit when it is renovated in Phase 3 of the improvement program, scheduled for completion in 2012.

The new elephant exhibit offers a state-of-the-art home for Louie, his mother Renee, and adult female Twiggy. The first phase has now been completed, and the three elephants are exploring its features and taking advantage of the enrichment opportunities that are provided throughout the facility—including the man-made shade.



An elevation of a shade structure in RAM Elements.