Unmilled Timber Frames Go High Tech, Replacing Steel

Product Review

Keep the beauty of round logs, and get more strength from an engineered wood structure, promises Wisconsin-based company WholeTrees.
by Candace Pearson [9]

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Round, unmilled timber might seem obsolete, but by using high-tech scanning and modeling, one company is bringing this form back into designers' repertoires at a cost that can compete with steel. And we're not just talking for a rustic log cabin aesthetic either: the company's fast-growing portfolio of projects includes contemporary designs at a high-end bakery, an industrial commercial building, and an outdoor pavilion.

For centuries, milling and planing have been used to cut wood into standardized sizes, but that process also reduces the material's strength. WholeTrees, a company out of Madison, Wisconsin, skips those steps, keeping trees intact for use in engineered structural systems.

Variability in shape does not mean the engineering is left to guesswork—quite the opposite. The company enables designers and engineers to work *with* the natural shape of its trees by providing exact dimensions that can be uploaded into BIM and CAD programs (each tree is scanned using LiDAR or Photogrammetry), as well as specific load and span guidelines.

Strength to replace steel and concrete

WholeTree products are classified as Heavy Timber Construction under the International Building Code (IBC), so they can replace steel and concrete in structural uses (or be merely decorative). Their strength is comparable to that of glulams or other engineered wood products, says Amelia Baxter of WholeTrees (see Engineering a Wood Revolution [10]).

That's possible because an unmilled tree is 50% stronger than its milled components, says Baxter. "The outer fibers of a tree transport all the nutrients; they are the most intelligent slice of the tree." Much of the strength is tensile, she says, as with a taut piece of rope. "If you slice off the outer fibers, the rope frays and is much more likely to break." A milled piece of wood will also warp—like how a sliced rope will unravel—displaying greater

variability in how it will dry, says Baxter.

Another way to think about this concept may be to think about the rings of a tree. Cutting a tree into rectangular planks leaves fewer of those rings intact, leaving just the strength of the fiber connections.

Of course, even the strongest looking tree will be compromised if it is rotted out inside. WholeTrees uses ASTM D2899, which is a visual method for grading round timbers for quality. “We hire a third-party national grader, Timber Products Inspection (TPI), for all straight poles and piles, and we use their grading practices on all non-straight arches and branching columns,” Baxter told BuildingGreen. “In addition, when TPI isn't involved…, we can opt to use Non Destructive Evaluation (NDE) techniques to verify material properties like grain density and rot.” That testing process involves sending transverse vibrations through the timber and comparing the results against those of small kiln-dried samples taken from that batch of trees.

Ingredient and supply transparency

For such strength, one might assume that WholeTrees uses traditionally high-value species. Not so. WholeTrees can make use of ash that has fallen prey to the emerald ash borer or invasive black locust, low-value hardwood aspen, and red pine—for which there is currently a diminishing pulp market. Forest Stewardship Council-certified wood (FSC) is available on request.

Furthermore, the company harvests trees that would be useless for milling, such as smaller trees that are not uniform. Most of the wood is harvested within 100 miles of the WholeTrees fabrication facility in Muscoda, Wisconsin, says Baxter, although the company is also looking to build operations in the Pacific Northwest. The company ships nationally.

WholeTrees products also carry a Declare Red List Free label and a Health Product Declaration [11], so it is easy to spot that borates are used as an insecticide and flame retardant. Although borates can be an occupational hazard, they are relatively benign compared with most other flame retardants and biocides.

The recommended natural finish, Heritage, contains tung and linseed oils, pine resin, beeswax, and D-Limonene. D-Limonene is an aquatic toxicant, but not peeling the bark off and leaving the wood unsealed would be risky, Baxter told BuildingGreen. “We’ve done that when an architect requested it, but it is hard to warranty and predict how the bark will handle over time.” Heritage finish seems to work well, and projects that use it haven’t had problems with off-gassing, according to Baxter.

A different workflow

Perhaps the biggest challenge to adopting this product is reconfiguring the design and construction workflow to accommodate it. Here’s how it generally works. Each tree is categorized in a WholeTrees digital database, searchable by height, diameter, branch span, and sweep. Design professionals download 3D files for whatever timbers they are interested in and incorporate them as they are designing in CAD/CAM software or creating the BIM model. An engineer approves the design, and the same files are then used to create the shop drawings for manufacturing. WholeTrees will the send the connection drawings and installation guidelines. (The company also offers installation services nationally.)

Not all projects will be ready to consider the placement of one unique tree at a time, so WholeTrees is prepared to take on as much or as little as needed. “We are able to assess the gaps and fill in wherever the team needs,” says Baxter. WholeTrees can partner with a design team and step in for the structural design scope, or the company can barely touch design at all. A project can use WholeTrees engineers or its own engineers.

It is great that WholeTrees can step in with the connection details, Carl Fink, P.E., told BuildingGreen, but it's always worth double or triple checking. Fink helped engineer the 57,000 ft^2 Festival Foods Grocery Store in Madison, Wisconsin, which uses WholeTrees for its beams and columns, combined with steel joist girders. “Close attention must be paid to the details of connection between tree elements and other elements,” said Fink. “Due to variability of trees, extra scrutiny during the shop drawing process must be made to assure proper fit up.”

Cost and unique uses

WholeTrees won’t likely be the cheapest option, but according to the company, the system falls comfortably within the conventional range for a structural system. Baxter says using it is usually more expensive than using steel or concrete for big box trusses, but less expensive than architectural-grade glulam.

Fink told BuildingGreen that WholeTrees was “surprisingly competitive with traditional steel framing systems” for the grocery store project.

Andrew Jordan, RLA, a landscape designer with WDM Architects, also specified WholeTrees in designing the Cleveland Zoo Tiger Passage. “We studied using their product on many parts of the [zoo] project, including the perimeter mesh support poles, arboreal trails to the overhead shift, and the overhead shifts themselves,” he told BuildingGreen. “We were pleasantly surprised that in many cases the cost of the WholeTrees products were very comparable to the steel alternative and in some places were less expensive than the alternative.”

Zoos certainly stand out as a nice (if niche) fit for this product. More mainstream has been a car port structure for the solar photovoltaic company SunCommon. “SunCommon is finding that there is a large demand for these solar car ports that are in very prominent public spaces, and they would like them to look unique and beautiful,” Baxter told BuildingGreen. A bulk order could mean WholeTrees will become a common sight.

[10] https://www.buildinggreen.com/feature/engineering-wood-revolution
[11] http://www.wholetrees.com/2016/wp-content/uploads/2016/09/WholeTrees-HPD.pdf
[12] https://www.buildinggreen.com/sites/default/files/ebn/TBGR_26-01.pdf
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