New River Train Observation Tower

Project Description:

Project Overview
The project for a train-viewing observation tower behind the Glencoe Mansion in Radford, Virginia is one piece of a comprehensive tourism development plan undertaken by the city tourism department. To conform with the client’s brief that the tower needed to look both backwards and forward – relate to the city’s railroad history while also showcasing the city’s movement into the 21st century – the team selected an emerging timber technology, hardwood cross-laminated timber (CLT), as the primary construction material due to a variety of material advantages. Because CLT is not easily accessible in the region, particularly hardwood CLT, the team not only undertook the design of the observation tower itself, but also sourced locally grown Yellow Poplar and coordinated the material development and construction logistics of locally-pressed hardwood CLT panels. The team also had to establish material transport and fabrication logistics due the general lack of infrastructure for CLT in much of the Eastern United States. The cutting-edge project establishes a series of benchmarks for mass timber construction in Virginia and the United States:

- The first project globally to use prefabricated, hardwood CLT modules
- The first project in the United States to use prefabricated CLT modules
- The first project in the United States to use structural hardwood CLT as a building enclosure system
- The first project in Virginia and the Southeastern United States to use hardwood CLT

Detailed Project Information
A diverse team of project collaborators and consultants including architects, sustainable biomaterial experts, structural and civil engineers, custom fabricators, and university students, among others, were involved in the project. As hardwood cross-laminated timber is not ANSI rated, the architects were able to use recently developed wood science and engineering data for Yellow Poplar cross-laminated panels to coordinate the local production of CLT with proper mechanical performance. The Yellow Poplar is locally sourced in Virginia and the panels were pressed, cut and digitally altered by the Southern Virginia Higher Education Center in South Boston, Virginia. With both material development [hardwood sourcing, structural testing, adhesive and coating testing, hydraulic pressing, etc] and final CLT panel fabrication complete, the project is set to break ground in August 2018.

Architecture students began the project in design studio with two architecture faculty being responsible for design development, construction details, logistics, coordination of multiple consultants, material acquisition and budget. The structure is a simple arrangement of a bridge connecting two volumes. A handicap accessible entry onto the bridge extends from an existing road and parking area. A second entry point is from a set of unused railroad-track rails that have been excavated by the project team to become a tree identification/nature walk. From the first volume entered, a bridge extends over a slope to a second volume from which the railroad track is visible. At its highest point, the structure stands 28 feet above grade with the walkway at 18 feet high. The two CLT volumes will be prefabricated in South Boston, Virginia and transported to the site to be lifted into place by a crane. The CLT volumes rest on a timber decking supported by a steel ‘collar’ and structural steel columns. The columns are arranged at various angles designed to help the structure blend into its forest environment. The CLT volumes are coated in a black pine tar in reference to the nearby railroad ties, both by sight and smell, and to help the structure blend into the forest. The volumes are perforated by CNC and hand-drilled holes to reduce the volume’s perceived mass, to mimic the forest’s dappled lighting effects, and to provide playful lines-of-sight for the viewer to the forest despite the user’s height. Among other design decisions, the aforementioned design strategies help to move the project beyond the brief’s minimum requirements and provide an engaging anchor project for the City of Radford’s tourism development plan.

Category of Submittal: Practitioner, Architecture
Upcycling low-value Virginia hardwoods into high-value, high-performance building products (1) is a significant benefit of CLT. Not only does selective harvesting of lumber improve Virginia forest health, but jobs are created for rural economies in South Boston, VA (2) as CLT is manufactured there. CLT helps urban economies like Radford reduce carbon emissions from construction (3) with rural economies like South Boston, VA benefiting financially (4), and improving economies means more construction (4). A win-win for all.
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Concept Diagrams - Client Brief and Design Response

Brief: Demonstrate the socially and technologically progressive attitudes of the city. Create a train observation structure that references the city’s rail history with an eye towards the future.

- Hardwood cross-laminated timber (CLT) was chosen as a primary structural material due to its low-carbon benefits, potential to increase speed of construction, natural aesthetics, ability to safely construct lightweight one-material cantilevered geometries, and the Yellow Poplar availability near the project site.

- The project’s CLT panels reference the railroad’s wooden train ties. The project’s exterior finish in black pine tar links the project to the city’s railroad history through the sense of smell. A history of polluting coal-fired locomotives are conceptually offset by carbon-negative mass timber construction.

Brief: Manage the difficult site in a cost effective and engaging way while improving the city park with a low-maintenance structure.

- Angled columns are designed to mimic tree trunks, thereby helping the structure blend into its dense forest environment.

- Perforations in the CLT are designed to relate to the forest’s dappled lighting effects and also to reduce the size of the structure’s perceived mass.

Brief: Engaging and informative for all ages. Equitable access for all users.

- Cubes are positioned to provide diverse experiences of the forest and train view for all user groups.

- Information about low-carbon construction and Radford’s railroad history is included on signs designed in collaboration with Sustainable Biomaterial students.

- Subtle material differentiation in the floor indicates different ‘speeds of use’ - spaces designed for seating/standing or walking.

- Old railroad tracks buried on site were excavated and are integrated into the structure as an alternative entry point.

- Some holes are cut on site with hand drills and some are CNC cut off-site. Both types of holes allow children and adults alike to peer through the CLT into the forest beyond regardless of the individual’s height. Digital and analog means of cutting are utilized to showcase the flexibility of CLT as a structural material.
The project provides views over Radford’s railroad tracks and down to the New River. Unlike previous design iterations, the final design clearly distinguishes between the prefabricated CLT geometries and the supporting structure below. An objective of the design was to develop a sense of lightness and integrate the project aesthetically with the surrounding forest. Angled steel columns help to dematerialize the base while allowing the CLT boxes to float within the tree canopy.

Design Process

- Cross-disciplinary design charette with Sustainable Biomaterials students
- Design development at building site
- Student design meeting, City of Radford
- Early design iterations
- Design development models
- Structural detail iteration
- Structural detail alternative iteration

Material Fabrication + Testing

- Local, sustainably-sourced Yellow Poplar
- Wood delivery to press
- Manual application by students of two-part polyurethane glue to custom CLT lamellas
- Operation of CLT press
- Surface treatment weathering tests (all natural pine tar and linseed oil)
- Structural testing to failure (rolling shear)
Panel Design and Fabrication

CLT panels are optimized to reduce milling time on the team’s 5-axis router. This is achieved both by negating the need to flip-mill and reducing time consuming, complex undercuts.

This inverted image of a tree’s dappled lighting effects provided inspiration for the perforations on the CLT boxes. The perforations allow light to pass through the CLT and also for the project’s users to see the layering of the CLT up close as they look through the holes. As CLT is a relatively new material in Virginia, such holes help to educate the public about the material’s unique characteristics.

Prefabrication axonometric indicating CLT panel placement and timber sub-structure

Floorplan indicating panel placement. A diversity in panel geometries allows for a diversity of forest experiences. This also creates a public-to-private hierarchy within the plan.
Assembly and Structure

(A) Hardwood CLT CNC milled with lap joints. Cable railing terminus is countersunk, anchored, and concealed into CLT to create a clean joint condition.

(B) 2"x6" and 2"x12" timber sub-structure prefabricated inside the CLT box for transport

(C) Wooden surface decking

(D) Untreated CLT on interior to maximize material aesthetics and tactility

(A) Steel ‘collar’ to provide rigidity and reduce pendulum vibrations. The collar is pre-welded and designed to be bolted together on site.

(B) Steel tube columns of varying diameter supported on helical pile foundations. A concrete collar is designed to surround the column-to-ground connection to provide additional support

(C) Hardwood CLT attached with bolts and self-tapping screws

(D) LVL support beams form the bridge that links both CLT boxes. The bridge provides lateral support to reduce vibrations.