Limb: Rethinking Heavy Timber Joinery Through Analysis of Tree Crotches

KASEY VLIET
University of Michigan

PETER VON BUELOW
University of Michigan

LIMB reconsiders historic heavy timber construction across cultures to develop new joinery methods by focusing on the natural occurrence of branch bifurcation in different wood species. Because of its low value, often the crotch of a tree is not harvested for commercial purposes. This project uses this vital element to design connections that replace traditional mortise and tenon or steel connections.

By replacing the joint with a single piece of wood that purposely grew for bifurcation in nature and moving the structural connection away from where vertical and horizontal members come together a stronger construction joint can be achieved. Beyond the reduction of waste and added value, this project has the following architectural ramifications:

1. Overall architectural design parameters relate to the natural angles of certain bifurcations. These restrictions have provocative formal implications.
2. A structural system that is scalable, from major tree bifurcations at the base suitable for larger buildings, to smaller bifurcations adaptable to furniture.
3. Different wood species sharing common structural capacities allow for cross-specie “crotches” as long as they share similar overall properties.

In the 17th century tree crotches were harvested for a variety of purposes from bracket systems in barn structures to structural joints in the construction of navy vessels (Encyclopédie Méthodique: Marine). In the 1960’s renown modern furniture designers such as Sam Maloof replaced two part mortise and tenon joints in their chairs with a singular bifurcated piece increasing connection strength and producing more sinuous form. More recently Whole Trees Architecture and Architectural Association program directors Martin Self and Emmanuel Vercruysse explore organic form aggregation using entire tree branches with bifurcations.

Our research sets itself apart by assuming a syntactical approach to design. We are not interested in unique form generation based on unique parts, something that is very well explored in the realm of digital fabrication, rather are constructing a reusable language of bifurcated joinery. There are a number of common natural angular occurrences in limb bifurcations and we have reduced those to a set of parts that can be “tuned” to develop diverse structural systems. The two types of crotches identified are: the “r” and “y” type. We have designed a digital fabrication workflow that extracts standardized milled parts from an inventory of salvaged material. The cataloguing of recurring angles and other physical properties inherent to different species of trees allows for further development of the structural possibilities of this system, which can be applied to nearly any type of tree bifurcation allowing for infinite combinations within the language of bifurcated timber joinery.

LIMB develops four spatially optimized structural systems that leverage the “r” and “y” crotch connection: branching nested structures, hexagonal organic dome, three-way triangulated columnar structure and two-way triangulated frame. By elaborating on the natural occurrence of tree bifurcation as a tectonic element using contemporary digital practices and combining different wood species and diverse cultural traditions to propose new timber construction systems. LIMB is simultaneously global and regional in its approach.
**LIMB**

**1. NEST STRUCTURE**
A family of bird nests is characterized by the natural geometry of elements that have been selected and arranged in a particular way. The nests are formed by interlocking and twisting various plumbing materials, creating a complex and intricate structure. These structures are not only functional but also aesthetically pleasing. The nests are designed to be both strong and flexible, allowing them to withstand the elements and adapt to changing conditions.

**2. TRIANGULATED COLUMN**
A triangulated column is a structural element that is made up of interconnected triangles. This design allows for maximum stability and support, making it ideal for use in various architectural applications. The column is formed by connecting triangular panels, each of which is supported by a network of smaller triangles. This system allows for the distribution of load and ensures that the structure can withstand heavy loads.

**3. TRUSS PORTAL**
A truss portal is a structural element that is used to support large, heavy loads. It consists of a series of interconnected triangles, which are designed to distribute the load evenly and prevent deformation. The truss portal is particularly useful in the construction of large buildings and bridges, where it is necessary to support significant weight.

**KEY**
- a. digital mockup of fabricated interior joinery
- b. 19th-century engravings: Mlle. Monique Illustrations with jointery
- c. OMC set list at 1 site source

Trellising through the Old Western hedges was often associated with hedges being formed by prop roots. These structures from a region that have (often) old hedges are often associated with some type of vertical structure. Much like the concrete also mentioned, columns of wedges from wooden...