MASS TIMBER INSTITUTE

UNIVERSITY OF TORONTO
JOHN H. DANIELS FACULTY OF ARCHITECTURE, LANDSCAPE, AND DESIGN

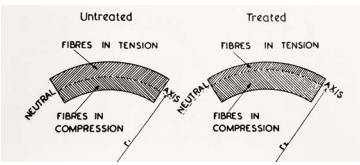
STEAM BENDING

An overview of steam bending techniques and applications with wood products.

BuildingInWood Bulletin #8

About Steam Bending

Steam bending is the process of steaming wood to make it more flexible, forming it into shape, and drying it to re-set the wood into the new shape [1]. Furniture scale application of steam bending is common, and its detailed craft is explored by designers like Petter Southall [2] and Eleanor Lakelin [3]. However, the technique can be used at both small and large scales. This bulletin illustrates the process and material constraints of this technique.



Wood performs better in compression, and in steam bending, more fibers are in compression, lending the wood more flexibility. Image Credit: Stevens, W.C, and Turner, N, 2006.

Material Constraints

Species Properties
Each tree species produces wood with varying strength and stiffness. Broader categories such as softwoods and hardwoods will also have different species properties as they vary in density. These strength and stiffness properties are available in tables in Engineering Design in Wood [4].

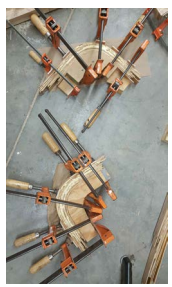
Steamer Size
This will dictate the scale of individual members to be bent. In order for the steam to envelop the wood and heat it uniformly, the steamer must enclose the member.

Steaming Time and Thickness
Larger elements require more time in the steam. One can estimate an hour and half for every inch of thickness to steam. In the project on the right, 1/8" wood was steamed for 10 minutes

Section Shape
In lumber with a square section, diagonal grains being bent might be inclined to splay. Sometimes, edges can be filleted beforehand to prevent this during bending. This results in a rounder section.

Process

Image on the left shows a set up for the steam treating process, which uses a steam generator connected to a steel barrel and covered with a woolen blanket.
Wooden box or a thick plastic bag can be used as other alternatives



Singly curved pieces of wood made with steam bent ash strips

Doubly curved piece of wood made with steam bent ash stirps

Strips of ash, cut and planed to a thickness of 1/8" are placed inside a steam filled barrel for treatment for a duration of 10 to 15 minutes before bending and clamping multiple layers around jigs to achieve the desired shapes. Leaving it clamped under tension for more than one hour makes the wood change its form and retain its new shape as it cools down. Now, the strips are unclamped, glued and re-clamped in position, which resulted in a strong laminated chunk of curved wooden panels after 24 hours of drying time.

Steam bent curvy handrail designed and built as part of the South Sioux City Orchard Facility, a CLT structure in Nebraska. Project work done by students of University of Nebraska-Lincoln, led by professor Jason Griffiths

Other heating methods:
Wood may be rendered equally suitable for bending by immersing it in boiling water or in heated wet sand [1].

Comparing bending and cutting:
Curved components may also be achieved by cutting the wood into shape. However, each method has its benefits:

Curved components created through bending rather than laminating and cutting wood to shape have more strength as any force applied is applied along the grain. Curving also uses less material than cutting out the form.

However, cutting curved components without bending offers precision and time sensitive construction. Bent components may slightly change form over time as the shape of wood fluctuates alongside its moisture content. Ultimately, the choice between bending and cutting will vary from project to project.

References and Further Reading

1. Stevens, W.C, and Turner, N. (2006). *Solid and Laminated Wood Bending.* Amsterdam, The Netherlands: Fredonia Books.
2. Tables. *Petter Southall*. https://pettersouthall.com/petter-southall-tables-2/
3. Gallery. Eleanor Lakelin. https://eleanorlakelin.com/gallery
4. CSA 086. *Engineering design in wood.* 2014.
5. Herzog, T., Natterer, J., Schweitzer, R., Volz, M., & Winter, W. (2004). *Timber construction manual*. Birkhäuser. https://doi.org/10.11129/detail.9783034614634

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Applications in Large Scale

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Large scale applications present their own challenges to steam bending because of the size of equipment needed and the material constraints of this technique - steam may not reach the centres of larger structural members. The following projects describe two different approaches which explore steam bending to construct large scale structures.

Sawmill Shelter

The Sawmill Shelter, built as a part of Architectural Association's (AA) Design+Make program demonstrates steam bending at the scale of the whole tree. This project had the goal of using the entirety of the log. This was achieved by partially slicing the log into layers and spacing them out during the steaming process, allowing steam to access portions deeper in the log. Upon bending, the layers enable portions at the inner curve and portions at the outer curve to take on a different radius, while coming together to form a single large structural member. [1]

The completed shelter features steam bent logs supporting slender finger-jointed timber laths

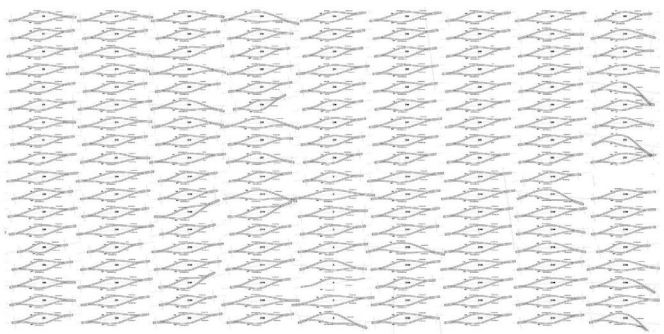
Spacers are placed between the layers of the 25cm diameter sliced log in preparation for steam bending.
Image Credits: Design + Make, Sawmill Shelter

Timber Seasoning Shelter

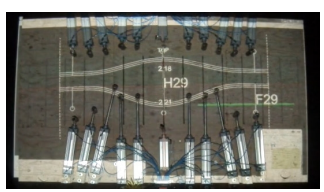
The Timber Seasoning Shelter, built as a part of AA's Design+Make program demonstrates the use of steam bending small components to be assembled into a larger overarching structure. While each component is singly curved, the hexagonal reciprocal frame pattern which guides their assembly enables a doubly curved, self supporting structure. [2]

To be self supporting, each component must be uniquely curved to create a change in depth where the structure requires it. The team developed a steam bending machine with adjustable curvatures rather than producing a unique jig for each component. [2]

The project sought to utilize the annual thinning of European Beech trees, which otherwise become firewood, in an architectural context. [2]



Many uniquely curved components comprise the structure.



Adjustable pneumatic rams form the steam bending machine

Steamer box steams individual chords.

Image Credits: Design + Make, Timber Seasoning Shelter

References and Further Reading

1. Design + Make. (n.d.). Sawmill Shelter. https://designandmake.aaschool.ac.uk/project/sawmill-shelter
2. Design + Make. (n.d.). Timber Seasoning Shelter. https://designandmake.aaschool.ac.uk/project/timber-seasoning-shelter/
3. Stevens, W.C, and Turner, N. (2006). *Solid and Laminated Wood Bending.* Amsterdam, The Netherlands: Fredonia Books.
4. Herzog, T., Natterer, J., Schweitzer, R., Volz, M., & Winter, W. (2004). *Timber construction manual*. Birkhäuser. https://doi.org/10.11129/detail.9783034614634

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