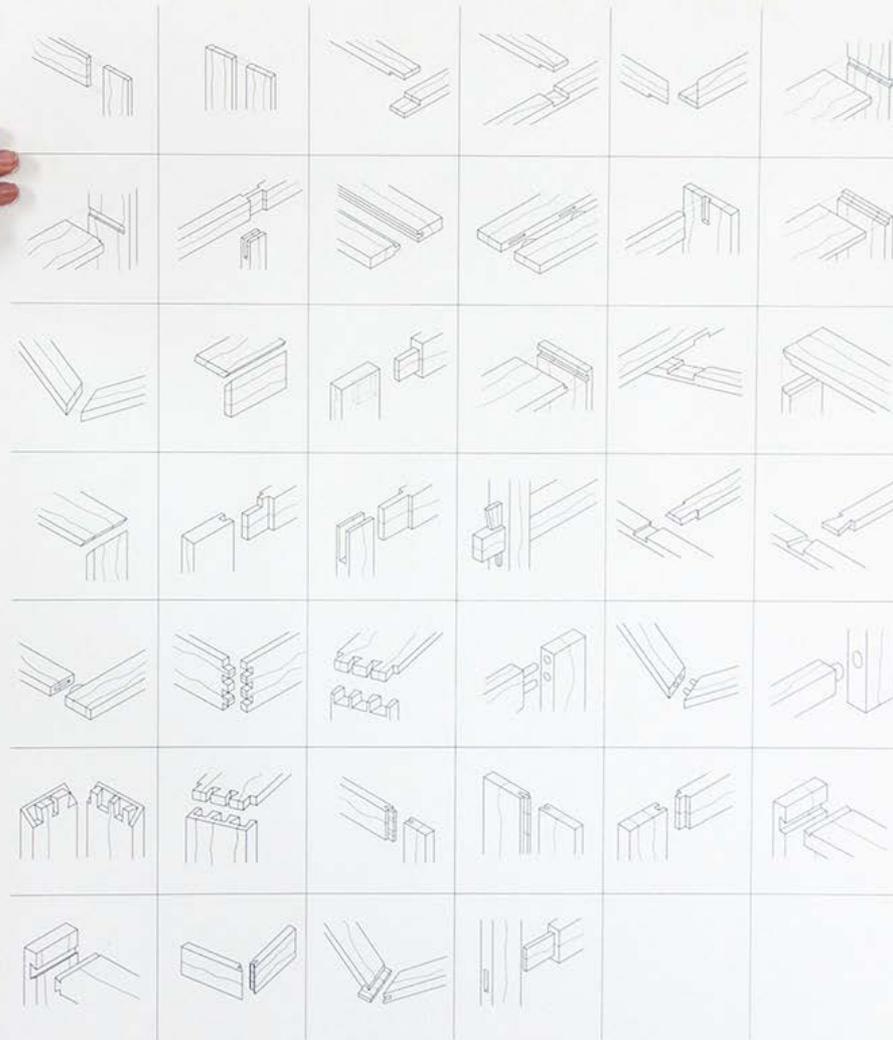


DIGITAL FABRICATION: JOINTS

ELEANOR MCKENNA
GRANT SASO
FELIPE LOPERA
OMAYRA DIAZ

JOINERY



JOINT FORMS

BASIC PRINCIPALS: Encyclopedia of wood joints

- Not developed for a particular function
- No evident of joint preference in construction
- Adapted in response to change and demand



JOINT FORMS

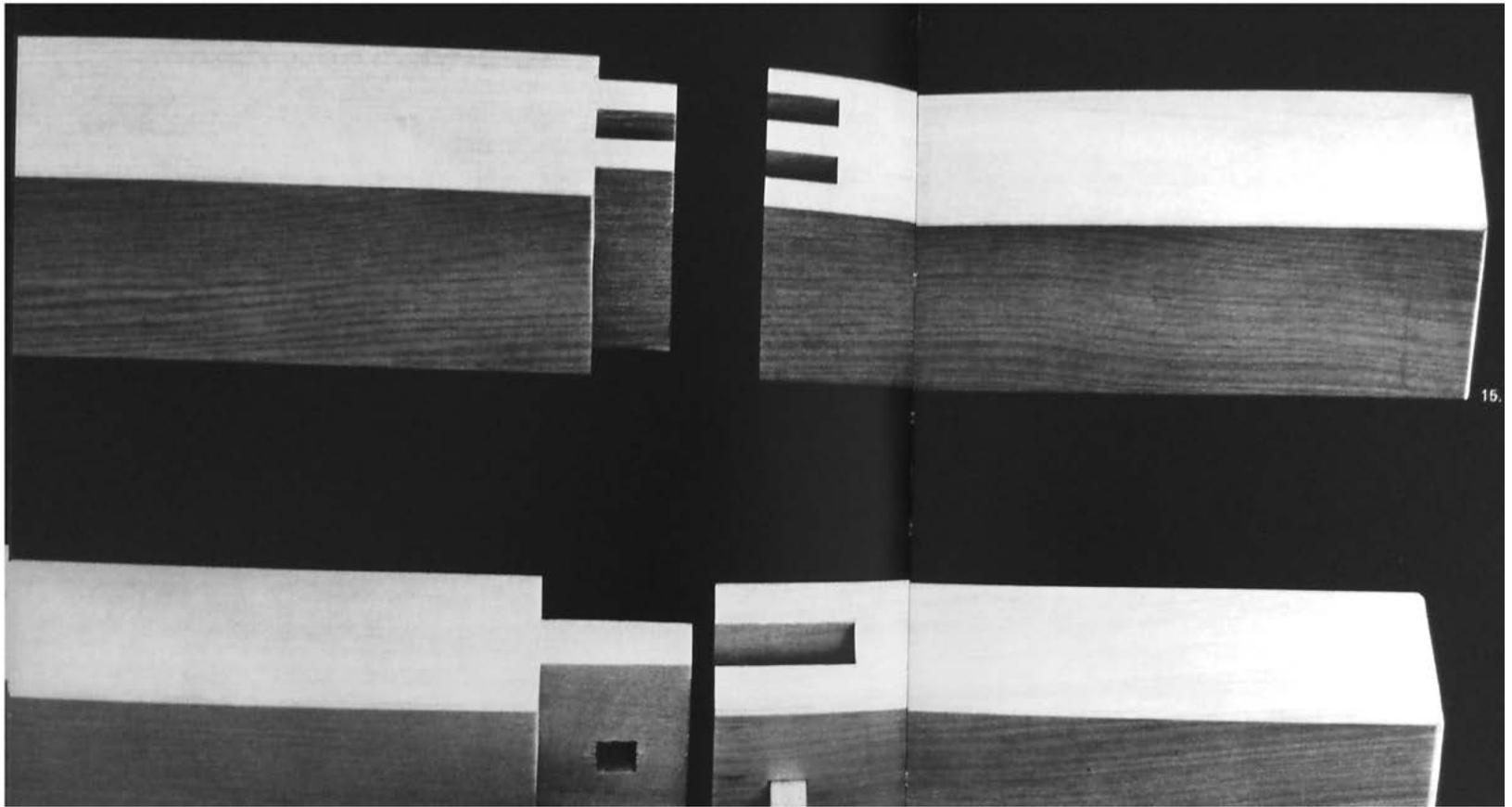
- Lap joints and mortise and tenon became more complex over time



JOINT FORMS

JAPANESE JOINERY:

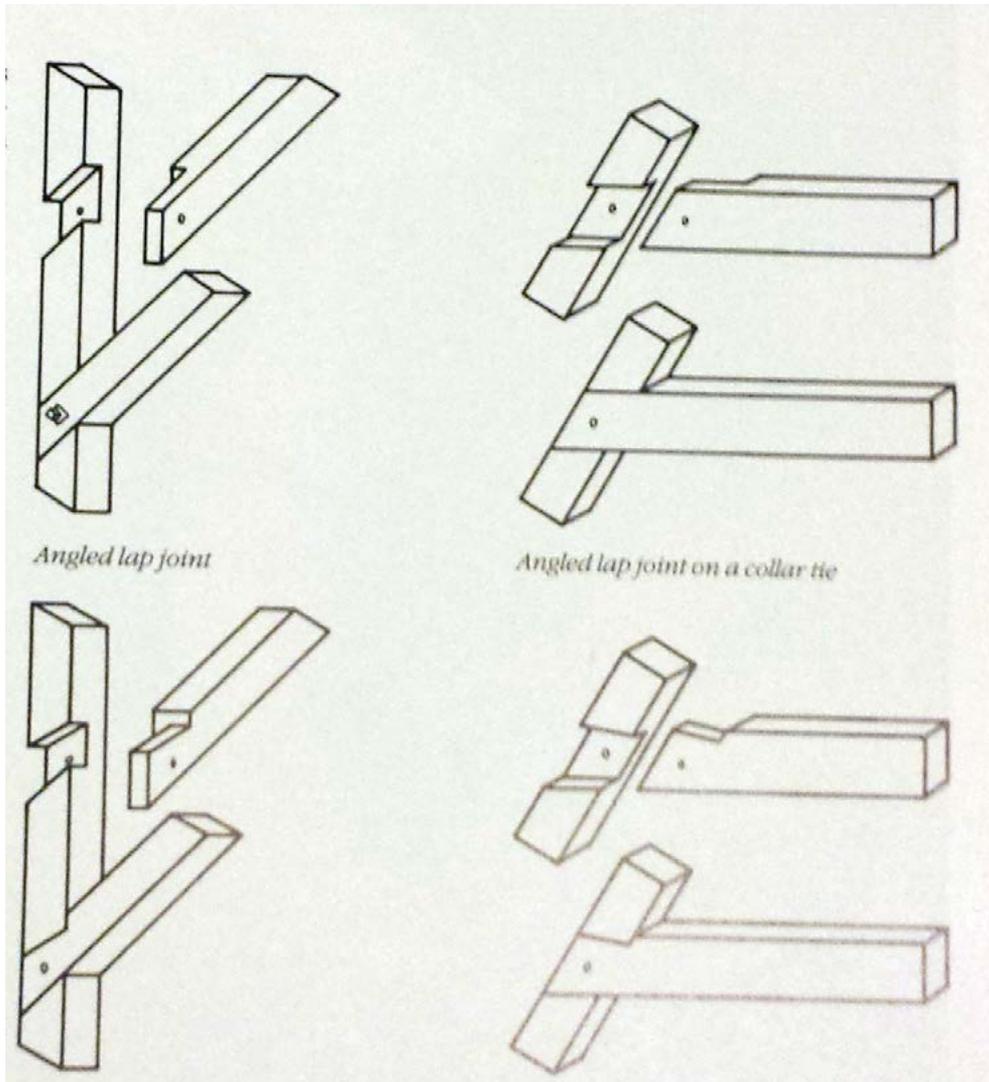
- Use of Splicing



JOINT FORMS

SOUTHERN EUROPE:

- Angled Joints



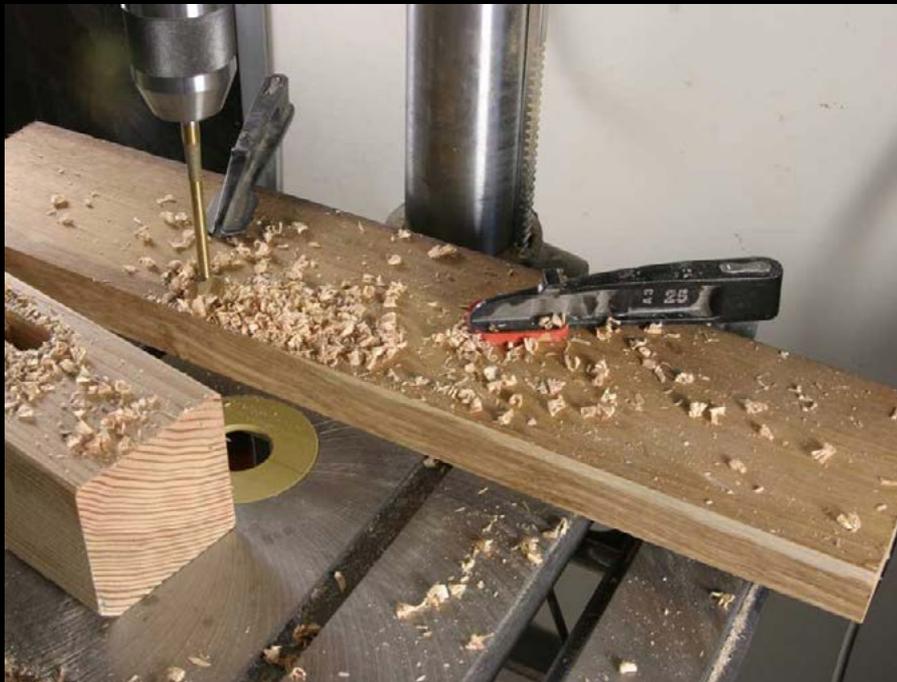
JOINT FORMS

HUMAN HAND

Joints were tested

- clasping
- grasping
- interlocking

- Evolution of joints through Tools



JOINT FORMS

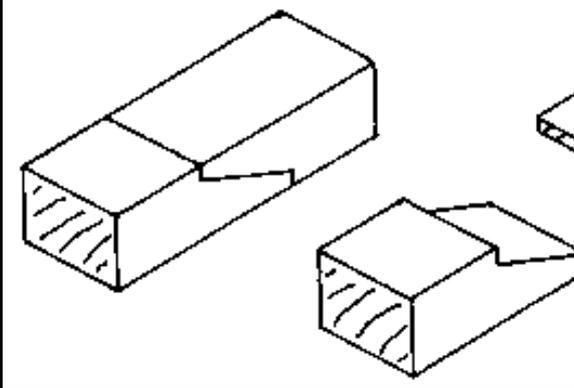
CHARACTERISTICS

- Strength, flexibility, toughness, appearance, etc.
- Derive from the properties of the joining materials
- How they are used

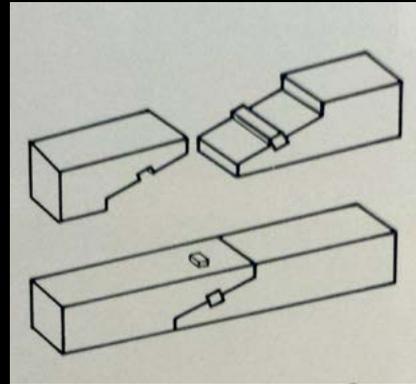


JOINT FORMS: SPLICING

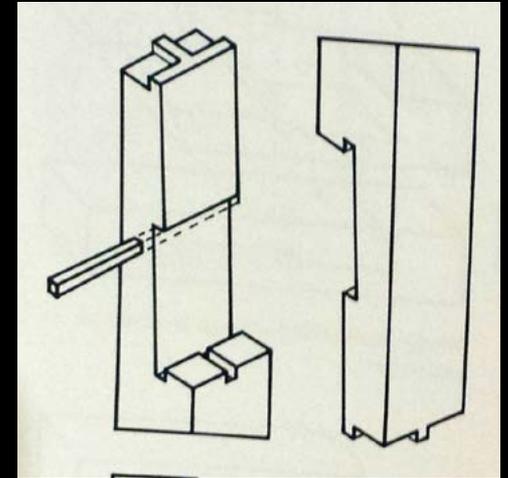
Table Splayed Joint



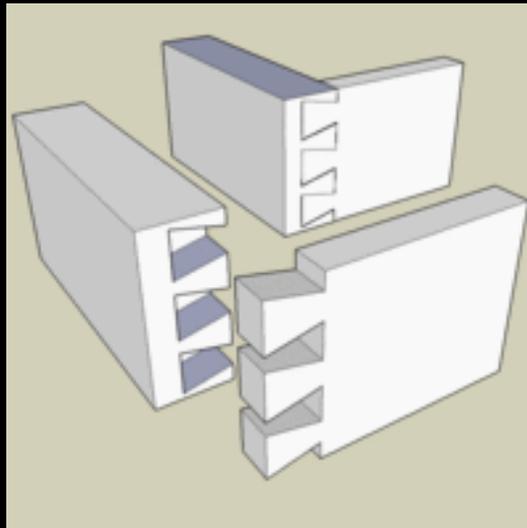
Gerber Joint



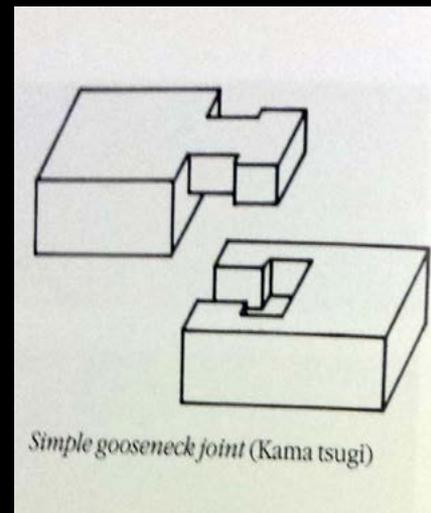
Wedge Locking Joint



Dovetail Joints

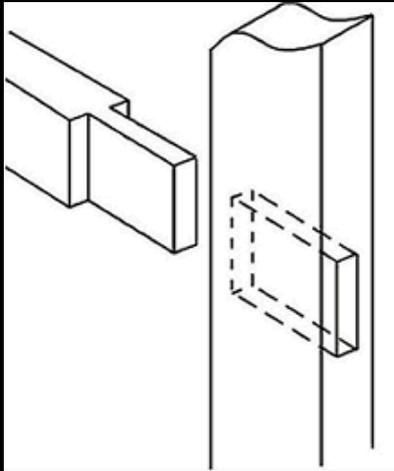


Gooseneck Joint

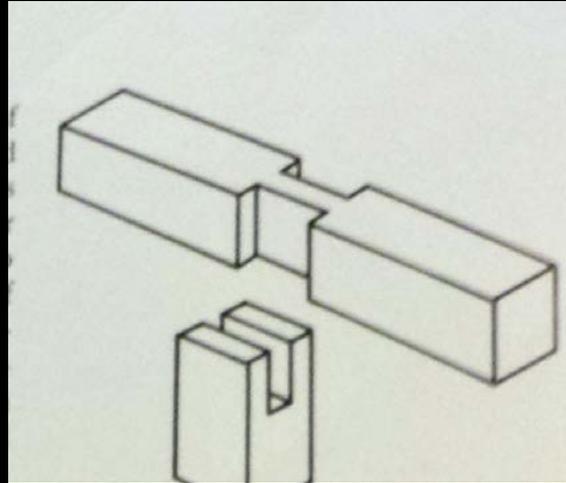


JOINT FORMS: COUNTER

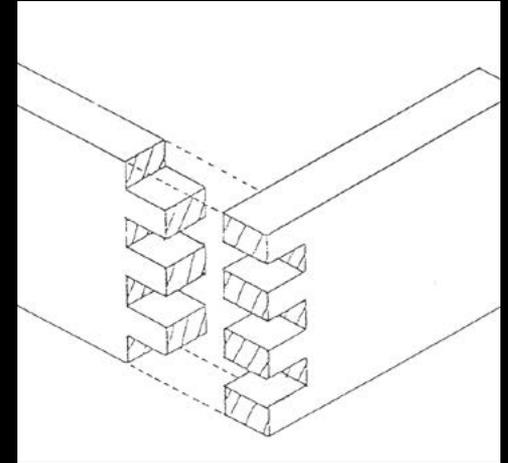
Mortise and Tenon Joint



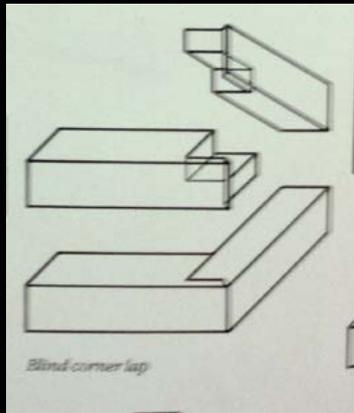
Bridle Joint



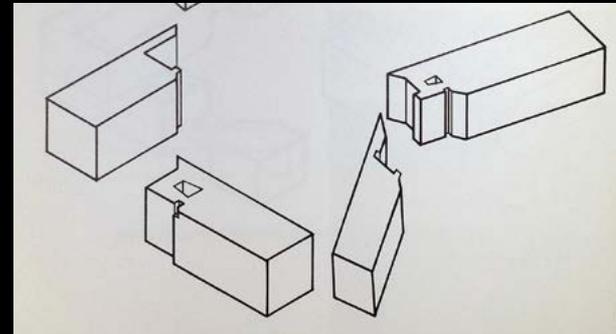
Box/ Finger Joint



Blind Corner Lap



Tongue Joint

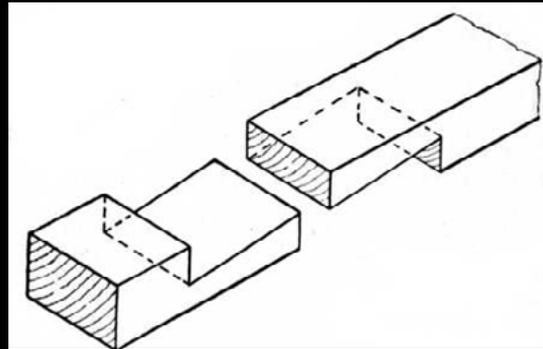


JOINT FORMS: EDGE TO EDGE

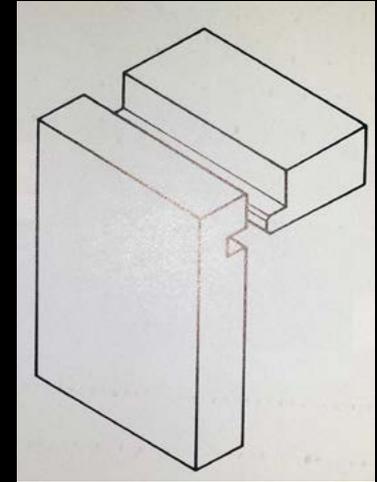
Rabbeted & Grooved



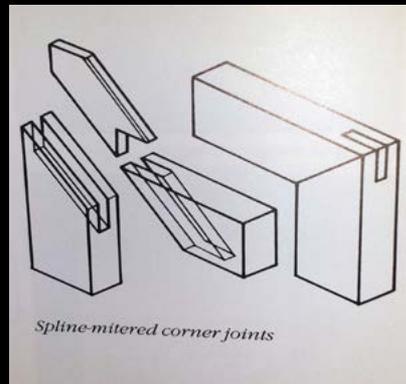
Lap Joint



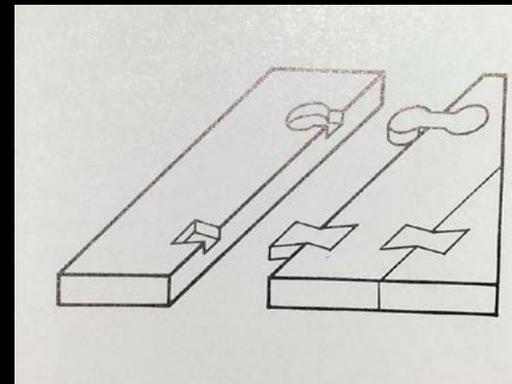
Tongue and Dado Joint



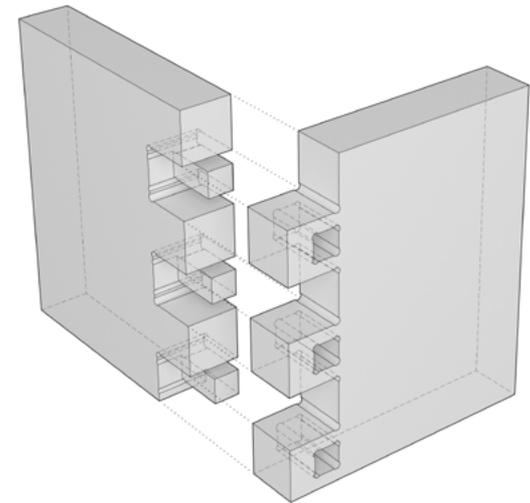
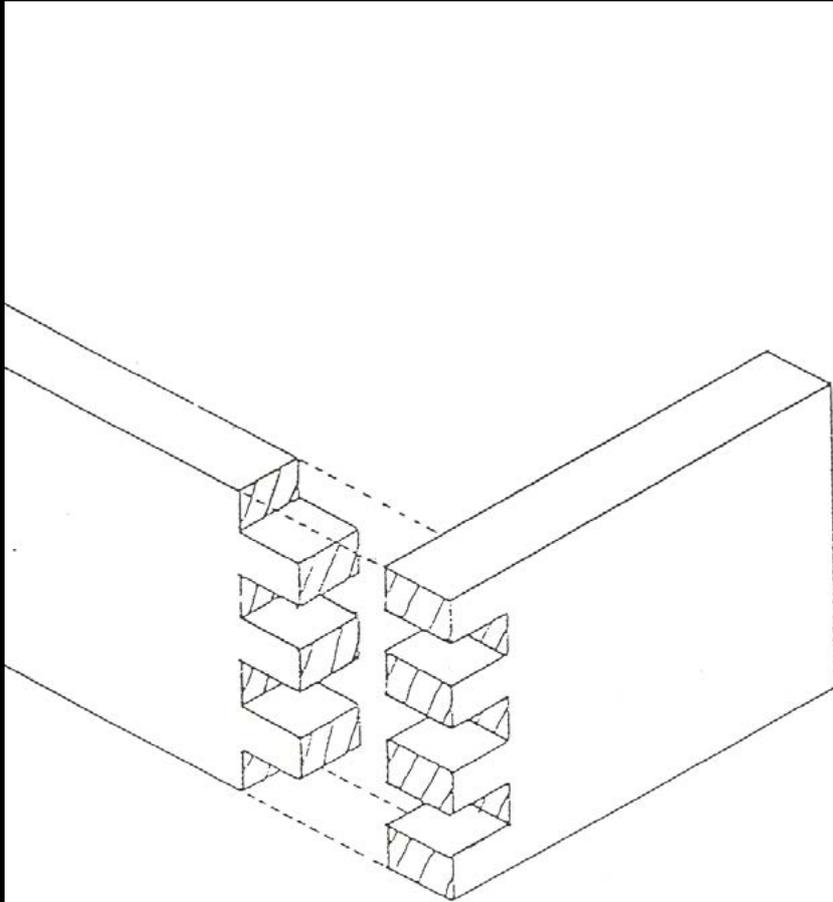
Spline Insert



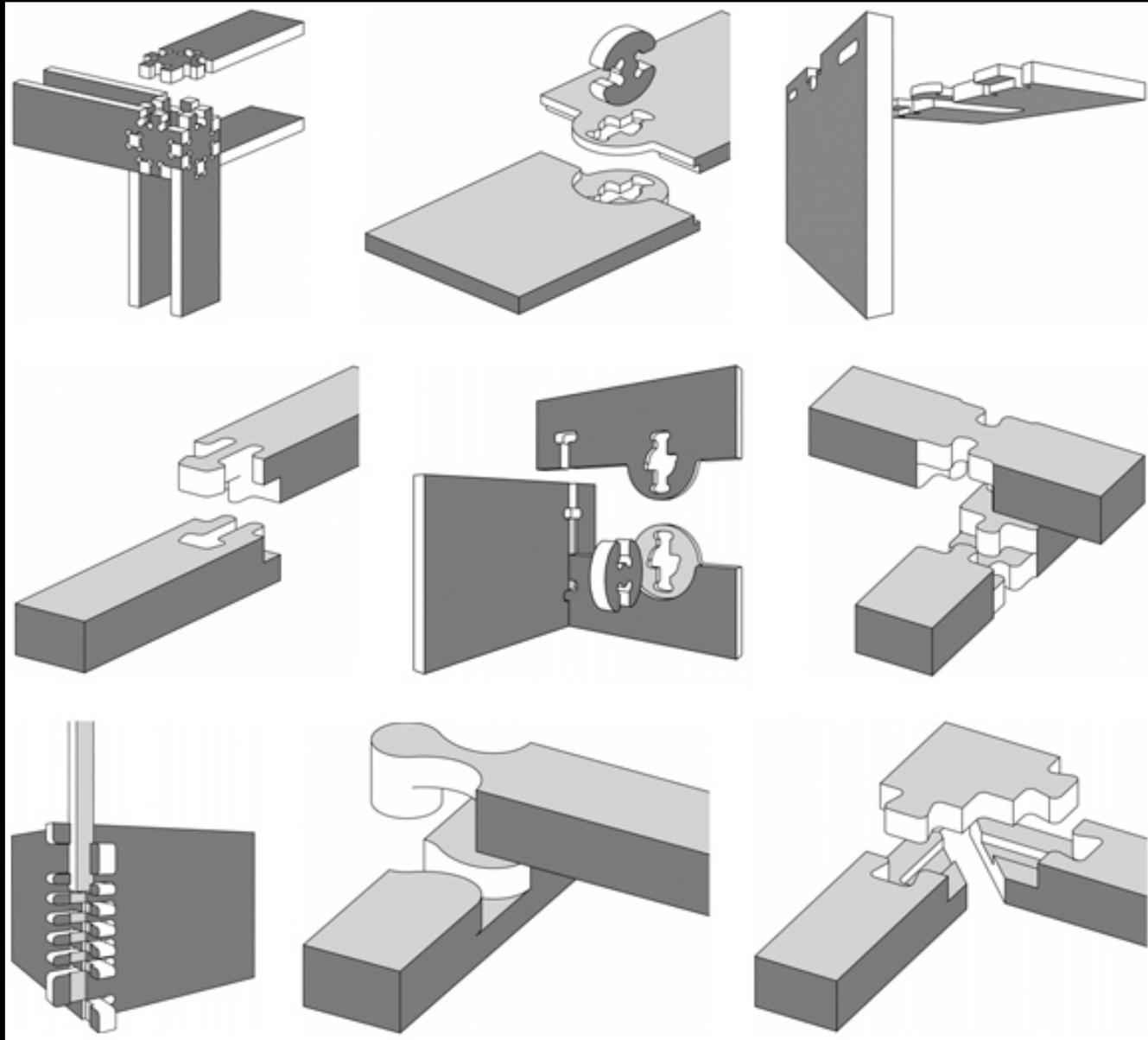
Butterfly Key



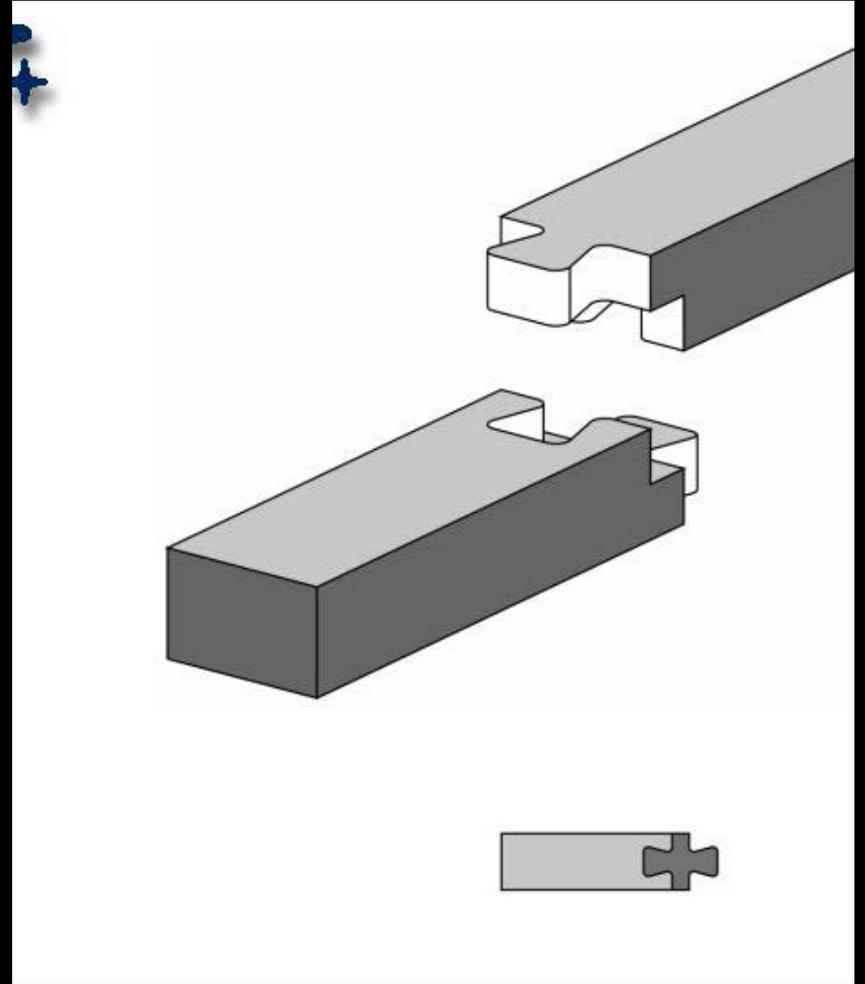
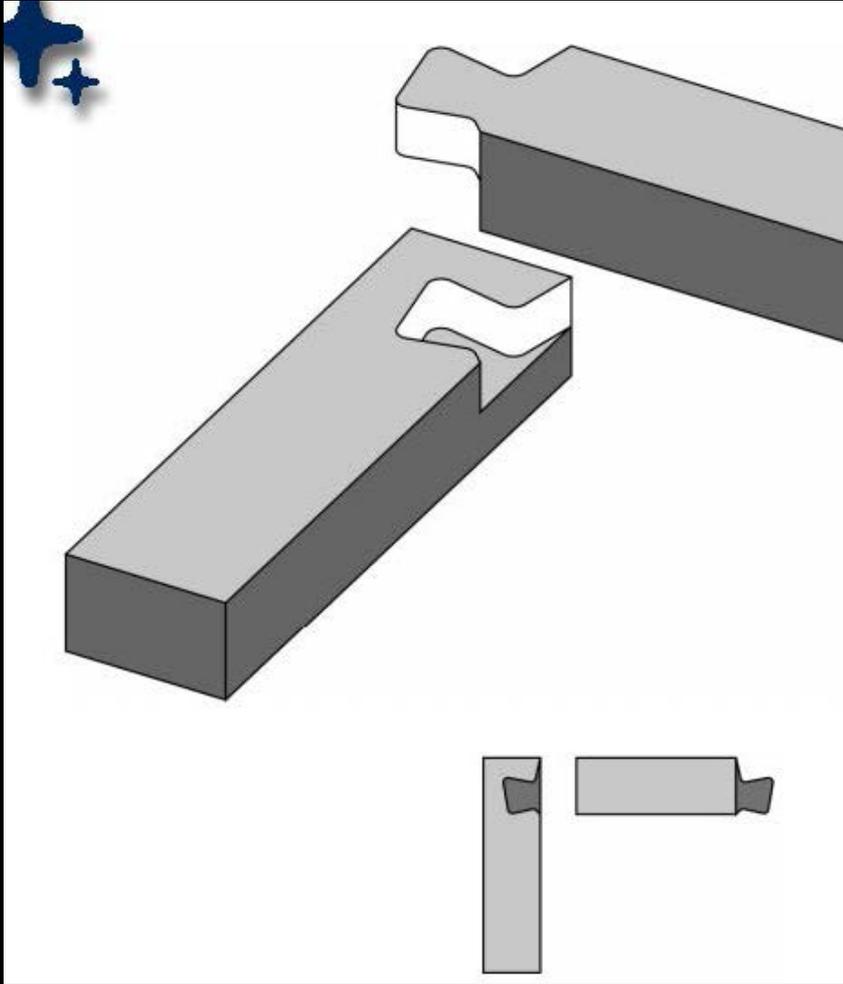
JOINT FORMS: TRADITIONAL vs DIGITAL

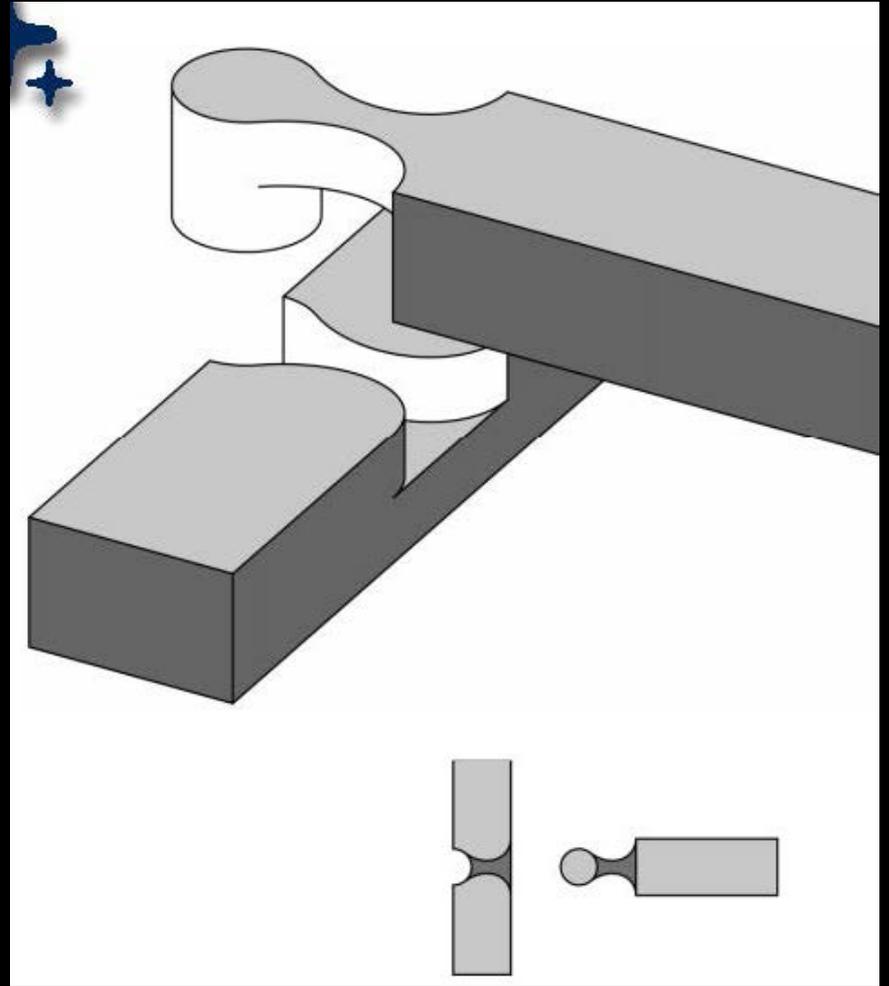
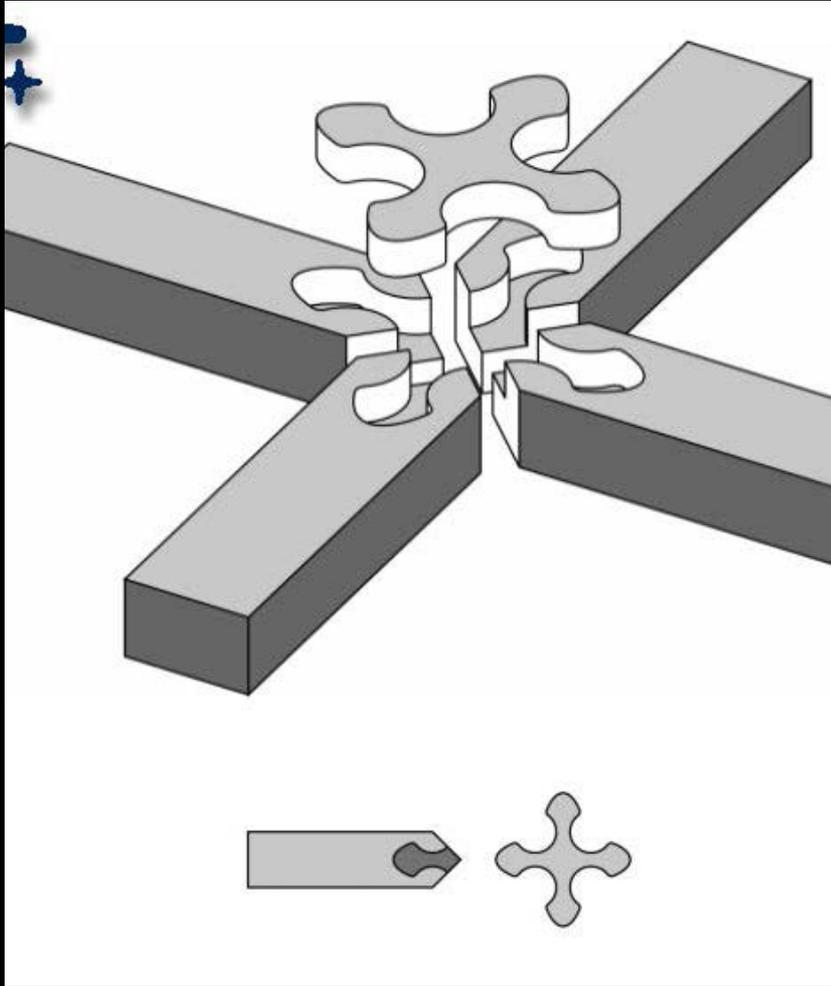


JOINT FORMS: DIGITAL

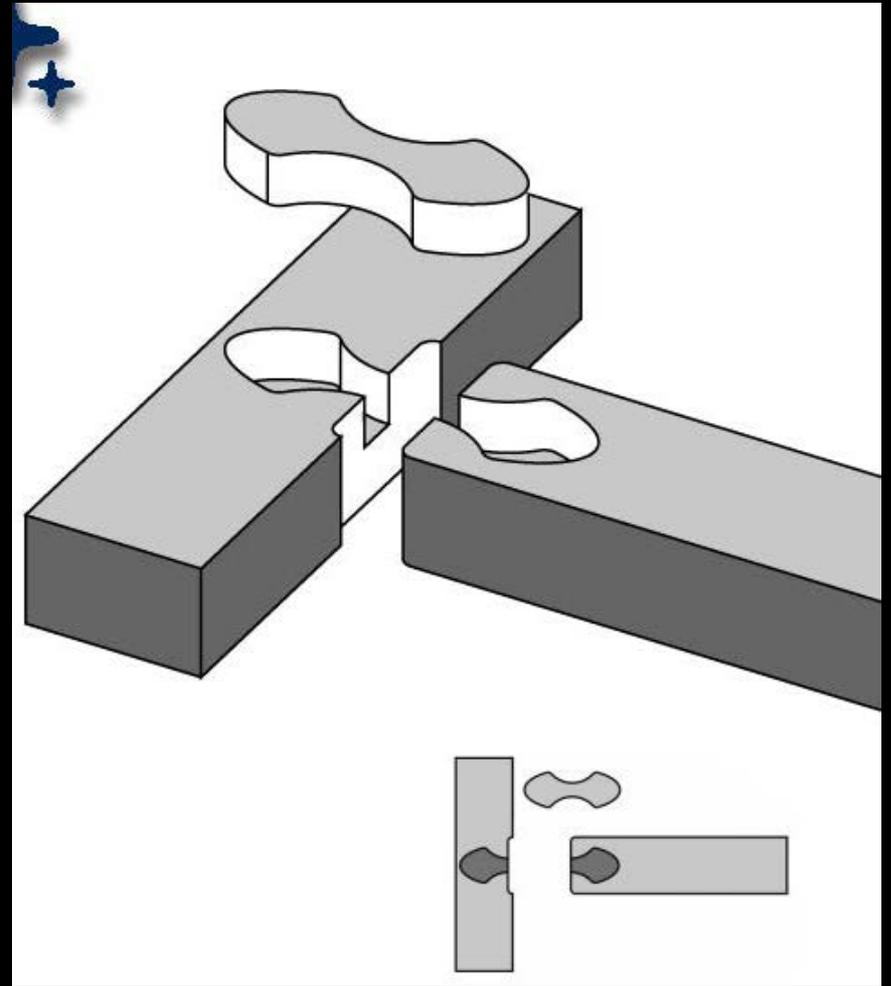
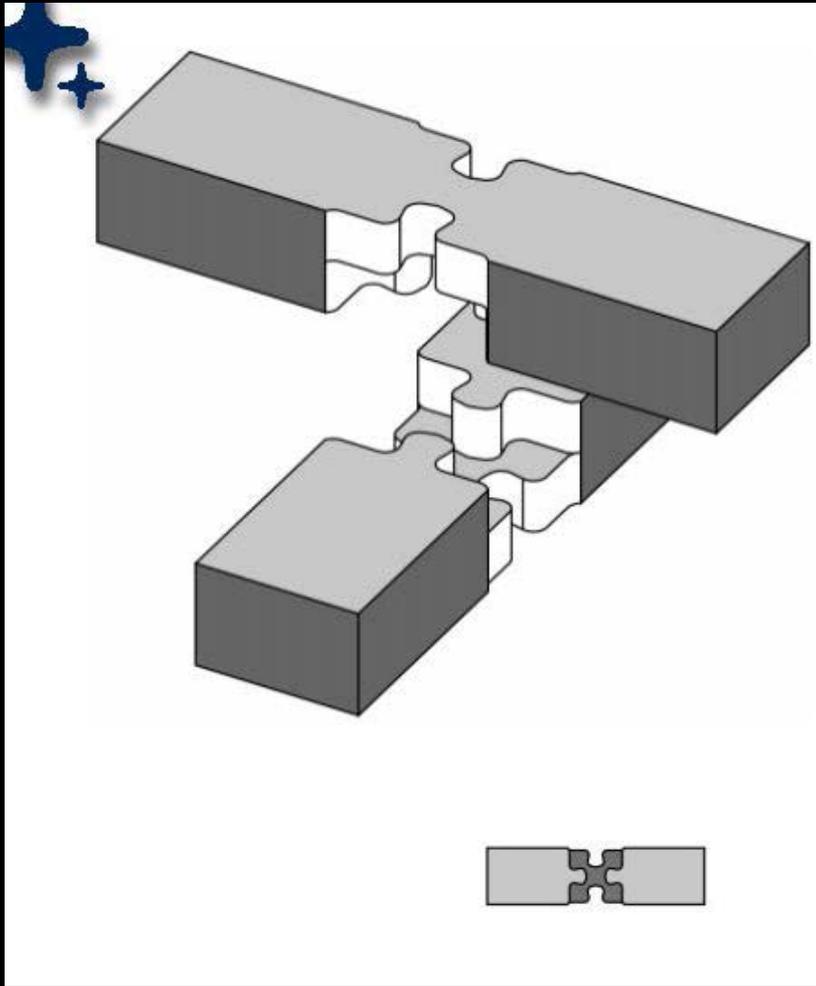


Jochen Gros's 50 Digital Wood Joints project

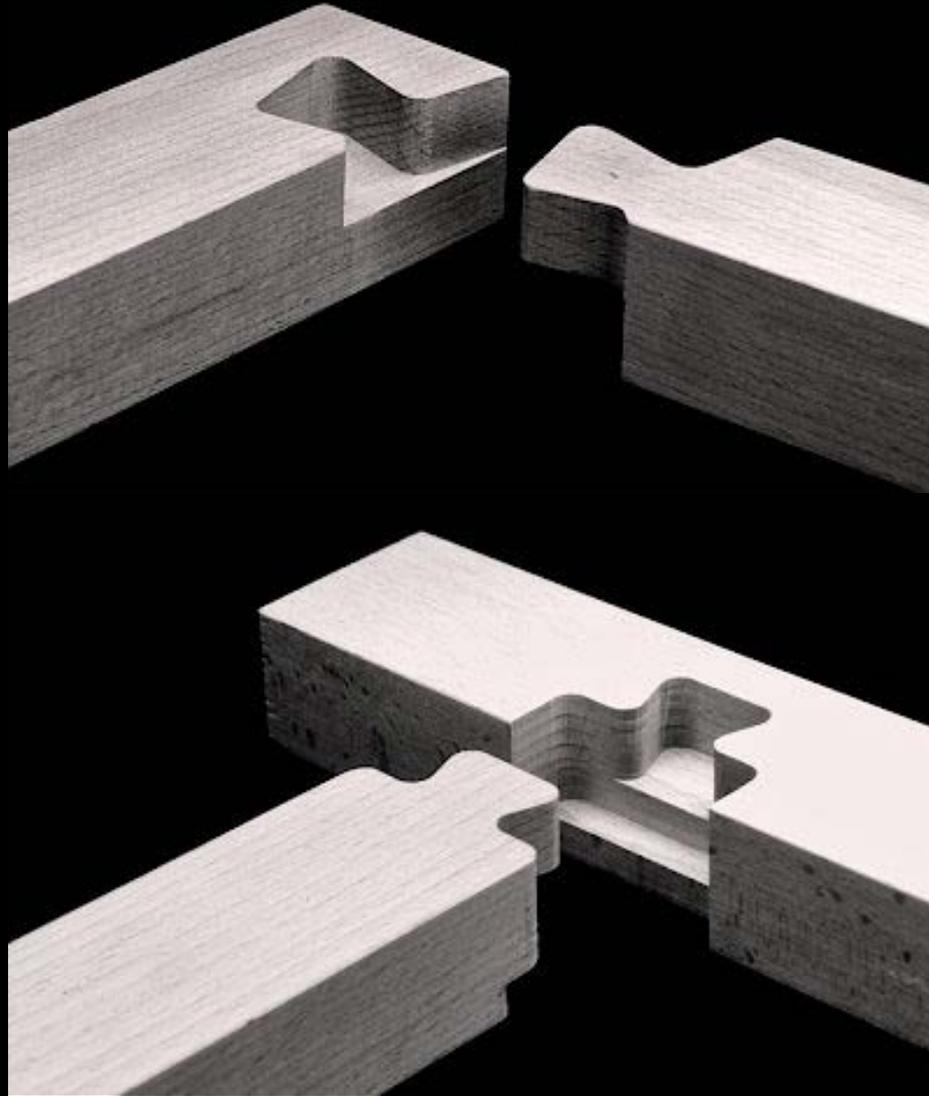




Jochen Gros's 50 Digital Wood Joints project



JOINT LOGIC: DIGITAL



Jochen Gros's 50 Digital Wood Joints project

CNC MILL

BASICS

- Allows for perfect joints to be fashioned in substantially less time
- Somewhat difficult to master, but provides endless opportunities
- Requires whole new skill set and way of thinking
- Ideas must be translatable to a computer program



CNC MILL

CONSIDERATIONS

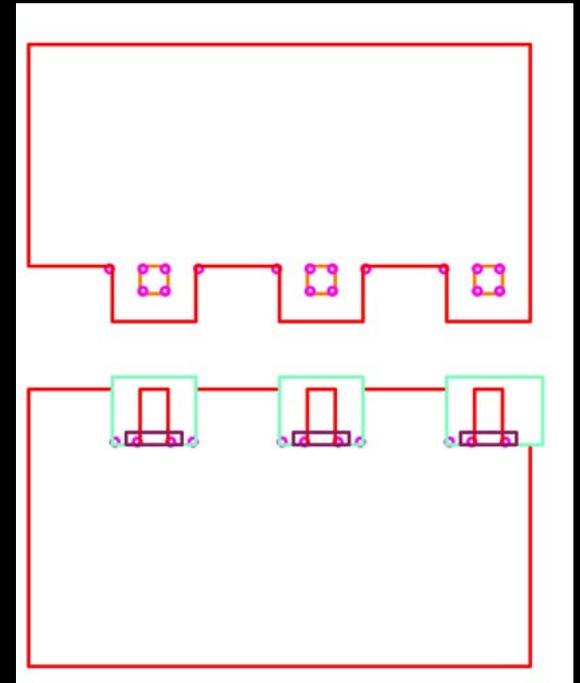
- Setting up your Rhino File
- 3-axis CNC Router (does not under cut)
- Size of Bit
- Inside Corner Problem
- Tolerances



CNC MILL

CONSIDERATIONS

- Setting up your Rhino File
- 3-axis CNC Router (does not under cut)
- Size of Bit
- Inside Corner Problem
- Tolerances



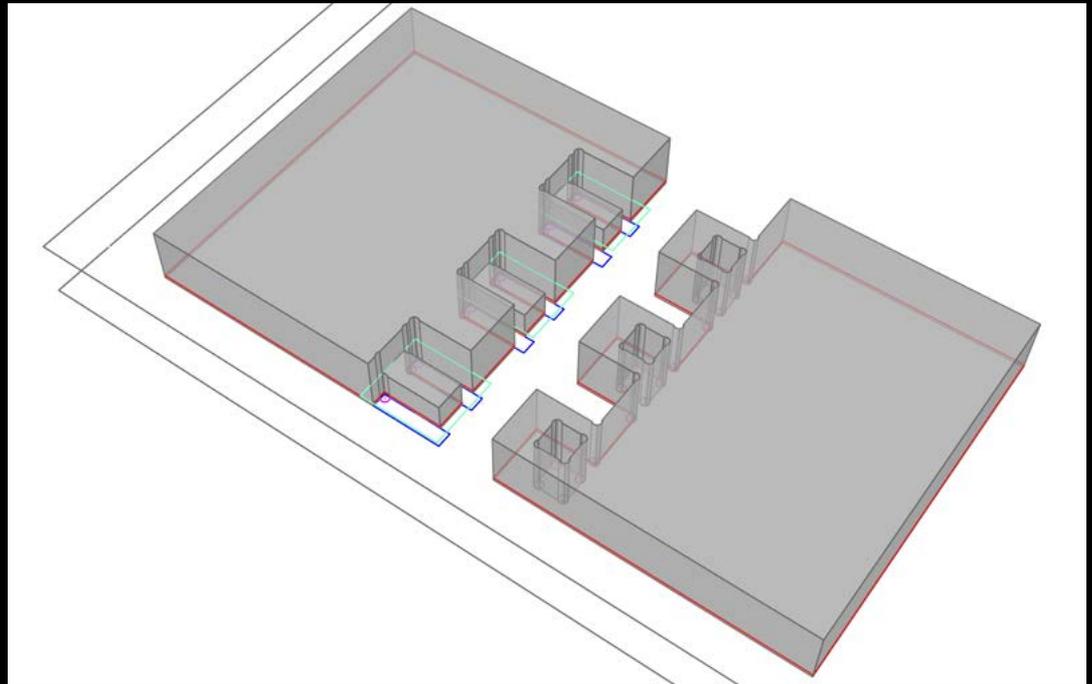
Layers - All Layers

| Name | | Material Library | Linetype | Print Width |
|--|--|------------------|-------------------|------------------|
| 4x8 SHEET | | | Continuous | ◆ Default |
| .9175 BOARDS | | | Continuous | ◇ Default |
| Pocket Planing 0.9" 3/8 Flat (OFFSETS) | | | Continuous | ◇ Default |
| Pocket 0.125" 3/8 Flat | | | Continuous | ◆ Default |
| Pocket 0.2" 3/8 Flat | | | Continuous | ◆ Default |
| Pocket 0.3" 3/8 Flat | | | Continuous | ◆ Default |
| Pocket 0.45" 3/8 Flat | | | Continuous | ◆ Default |
| Profile ThruCut Inner 3/8 Flat | | | Continuous | ◆ Default |
| Profile ThruCut Outer 3/8 ONIONSKIN | | | Continuous | ◆ Default |
| Pocket Holes 1" 1/8 Flat | | | Continuous | ◆ Default |
| Finger ThruCut 0.45" 1/8 Flat | | | Continuous | ◆ Default |
| Finger ThruCut 0.9" 1/8 Flat | | | Continuous | ◆ Default |
| Pocket Holes 0.5" 1/8 Flat NULL | | | Continuous | ◆ Default |
| 3D-X Axis 1/4 Ball | | | Continuous | ◆ Default |
| 3D-X Axis TAPER 1/4 Ball | | | Continuous | ◆ Default |
| Profile ThruCut Outer 1/4 REAL | | | Continuous | ◆ Default |
| 2 Curve Machining | | | Continuous | ◆ Default |
| Engraving Pass | | | Continuous | ◆ Default |

CNC MILL

CONSIDERATIONS

- Setting up your Rhino File
- 3-axis CNC Router (does not under cut)
- Size of Bit
- Inside Corner Problem
- Tolerances



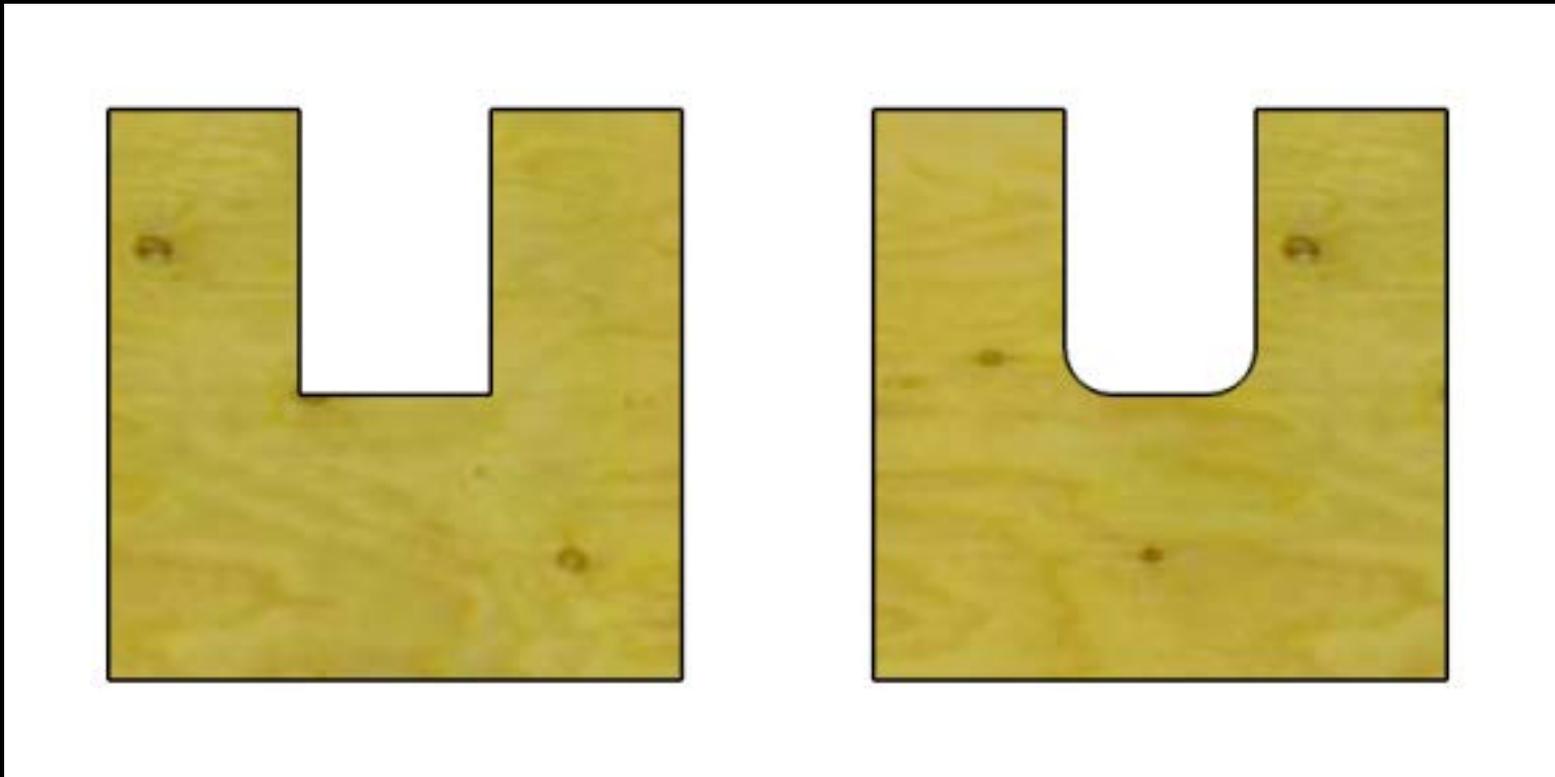
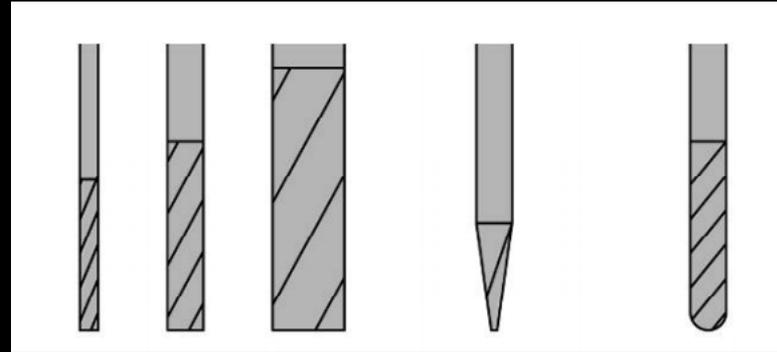
Layers - All Layers

| Name | | | Material Library | Linetype |
|-------------------------------------|-----|---|------------------|-------------------|
| 4x8 SHEET | ✓ | ■ | | Continuous |
| OFFSETS | 💡 🔒 | □ | | Continuous |
| .9175 BOARDS | 💡 🔒 | ■ | | Continuous |
| Pocket Holes 1" 1/8 Flat | 💡 🔒 | ■ | | Continuous |
| Pocket Planing 0.9" 3/8 Flat | 💡 🔒 | ■ | | Continuous |
| Pocket 0.45" 3/8 Flat | 💡 🔒 | ■ | | Continuous |
| Profile ThruCut Inner 3/8 Flat | 💡 🔒 | ■ | | Continuous |
| Profile ThruCut Outer 3/8 ONIONSKIN | 💡 🔒 | ■ | | Continuous |
| Profile ThruCut Outer 1/4 REAL | 💡 🔒 | ■ | | Continuous |
| Finger ThruCut 0.9" 1/8 Flat | 💡 🔒 | ■ | | Continuous |

CNC MILL

CONSIDERATIONS

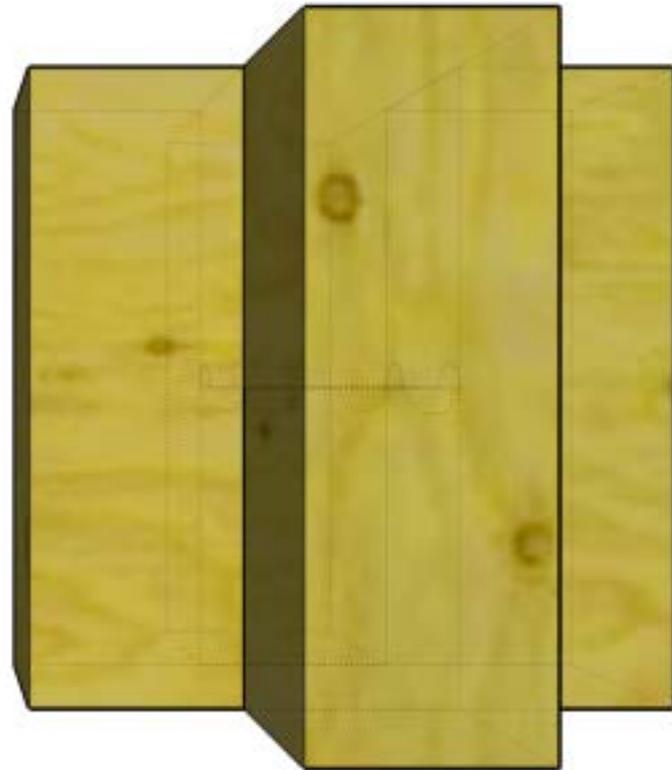
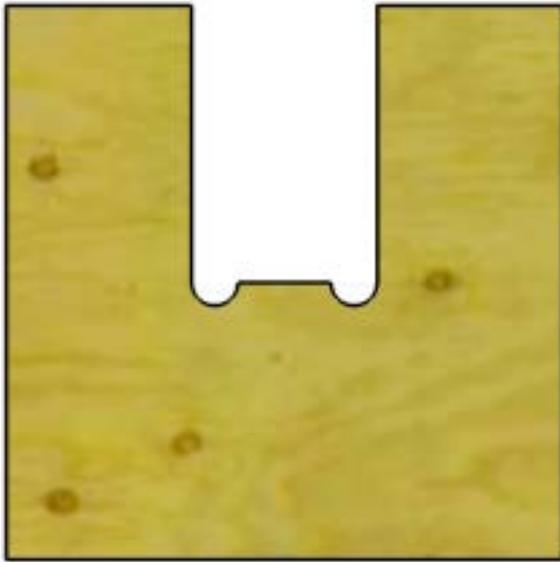
- Setting up your Rhino File
- 3-axis CNC Router (does not under cut)
- Size of Bit
- Inside Corner Problem
- Tolerances



CNC MILL

CONSIDERATIONS

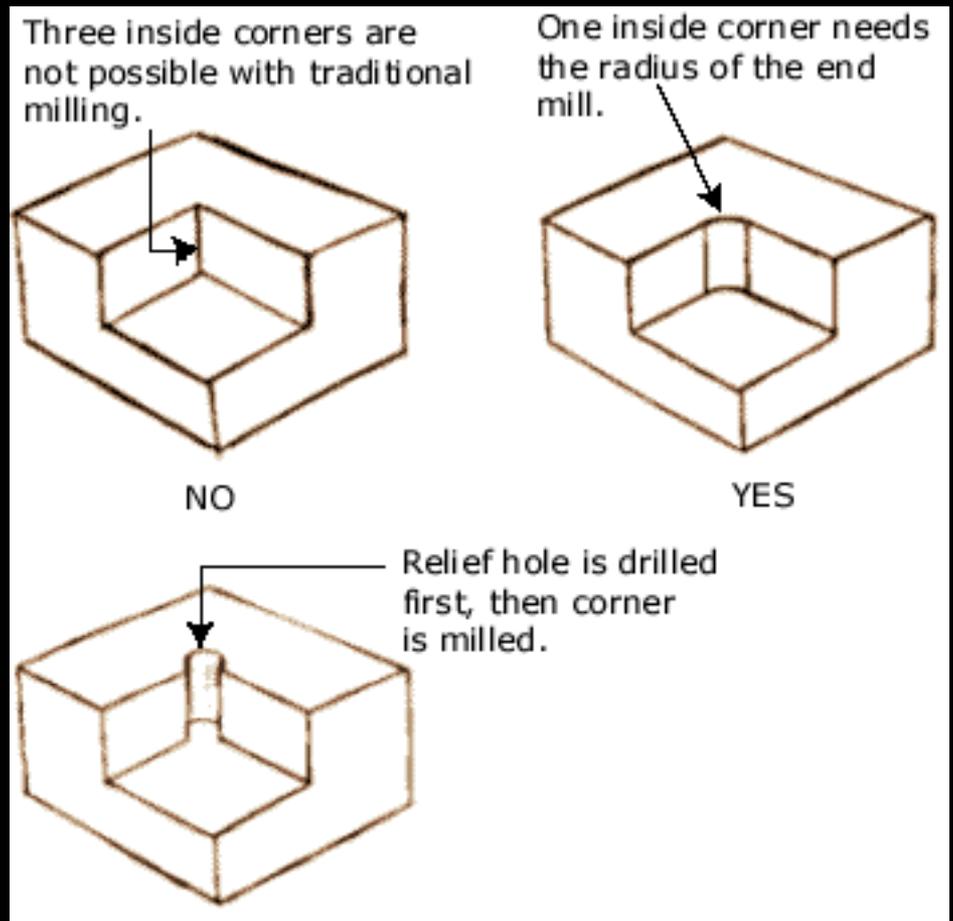
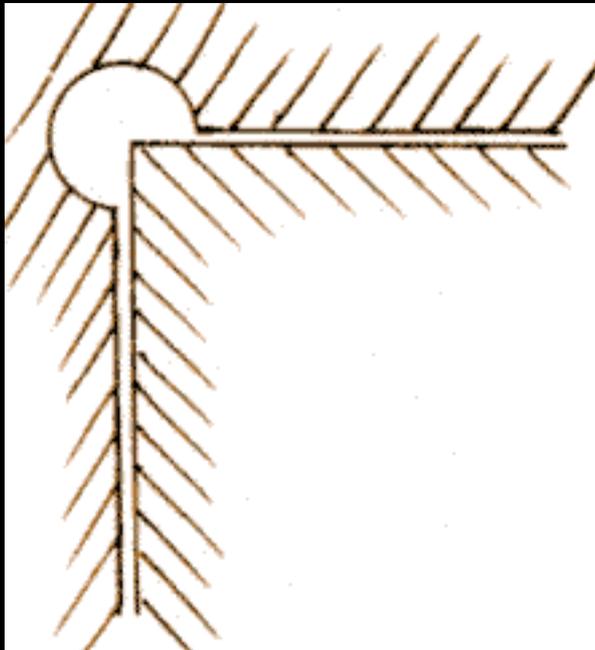
- Setting up your Rhino File
- 3-axis CNC Router (does not under cut)
- Size of Bit
- Inside Corner Problem
- Tolerances



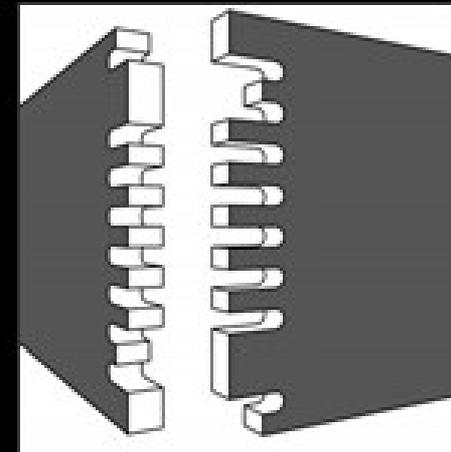
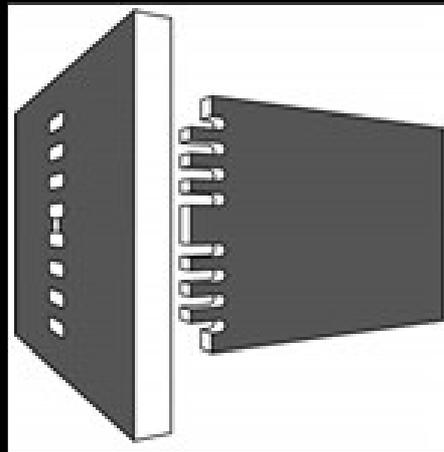
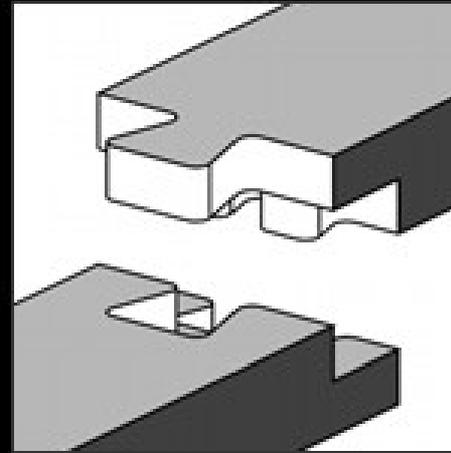
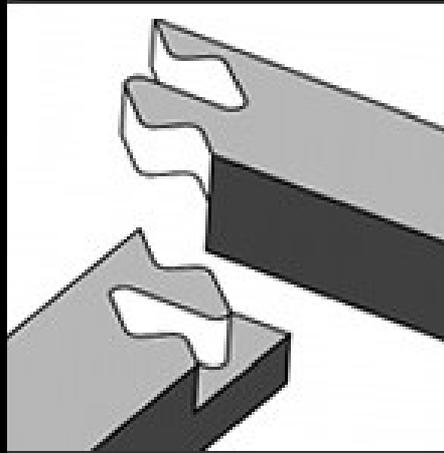
CNC MILL

CONSIDERATIONS

- Setting up your Rhino File
- 3-axis CNC Router (does not under cut)
- Size of Bit
- Inside Corner Problem
- Tolerances



CONNECTIONS



Two and Three Piece Linear Connections

Broken down into several categories depending on the angle and orientation of the two pieces

Further broken down by connection appearance desired

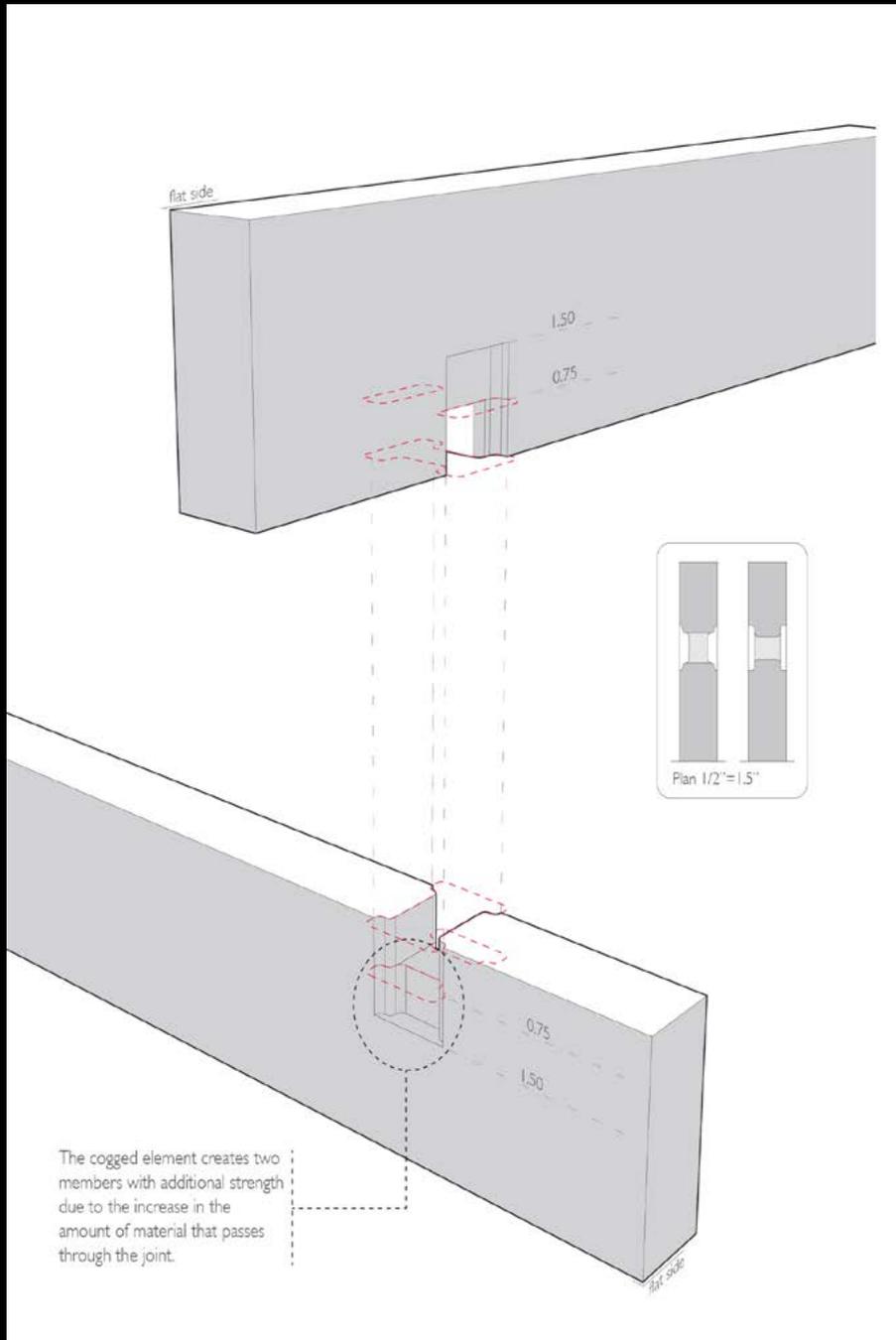
Lap, Mortise and Tenon, Scarf, etc.



Cogged Lap

Provides additional strength, but the pieces do not lie flush

Can be applied as sheet to sheet, frame to frame, or sheet to frame

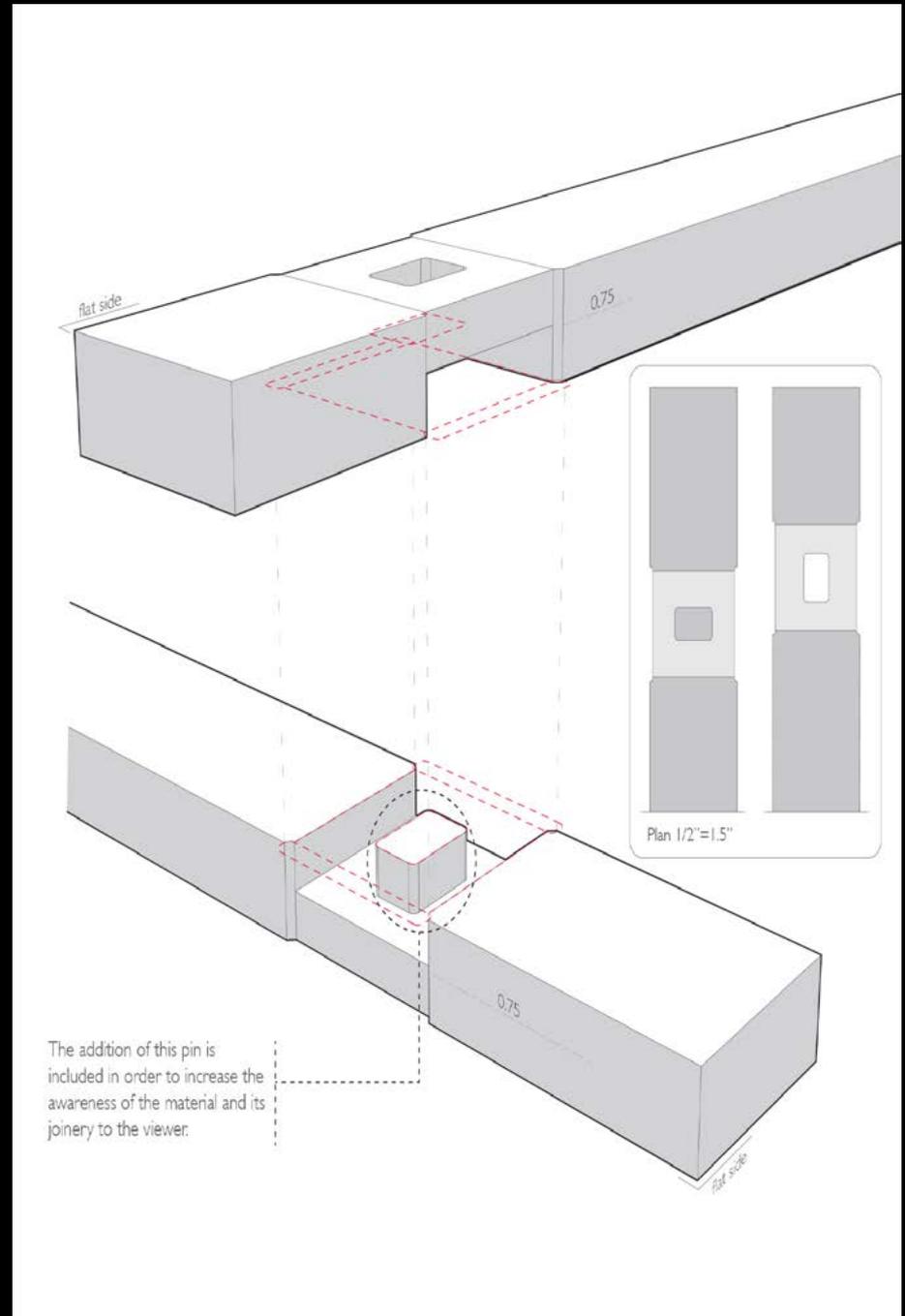


Crossed Lap

Requires half of the material which limits the strength

Pieces lie flush, allowing wider array of use

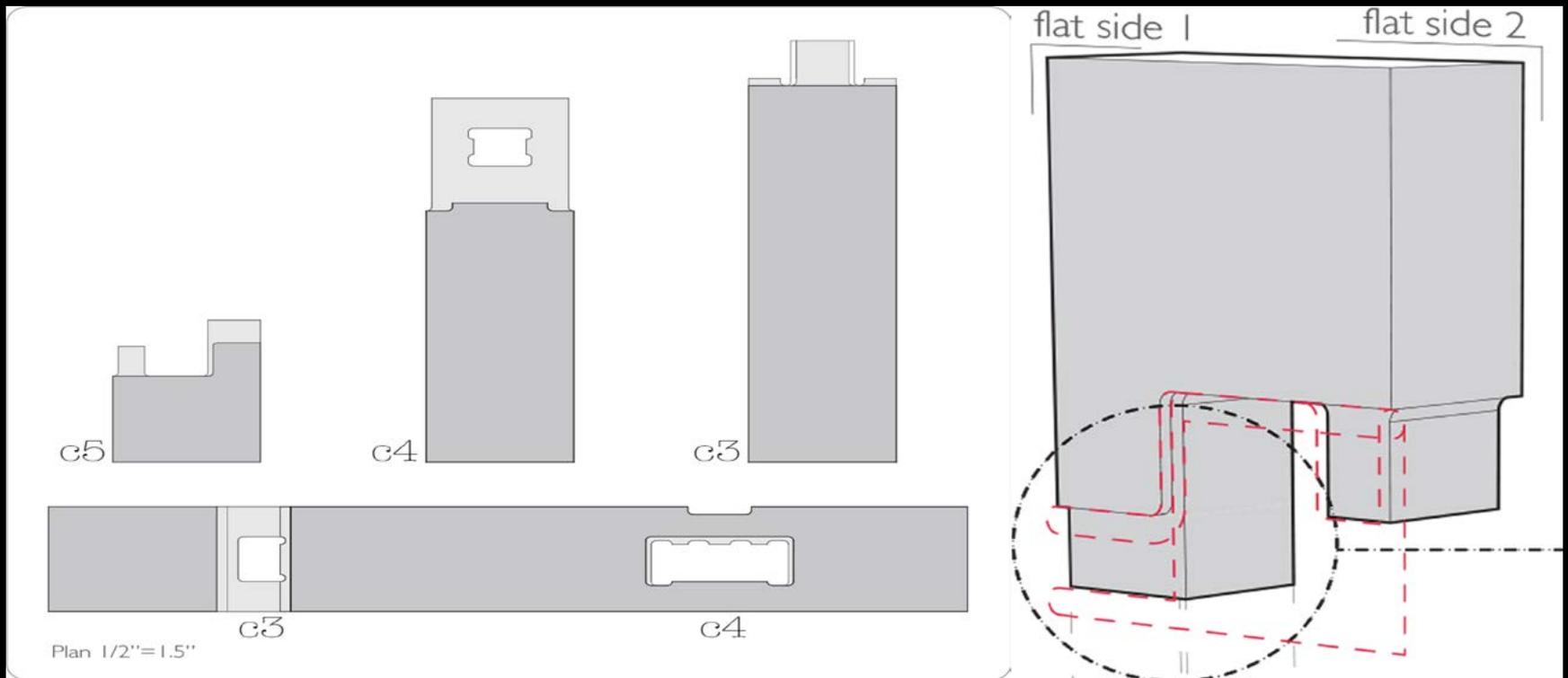
Can be applied as frame to frame or sheet to sheet



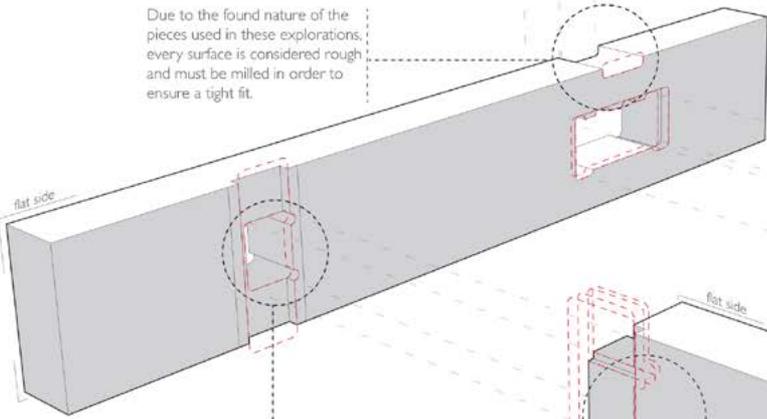
Mortise and Tenon

Provides additional strength, but the pieces do not lie flush

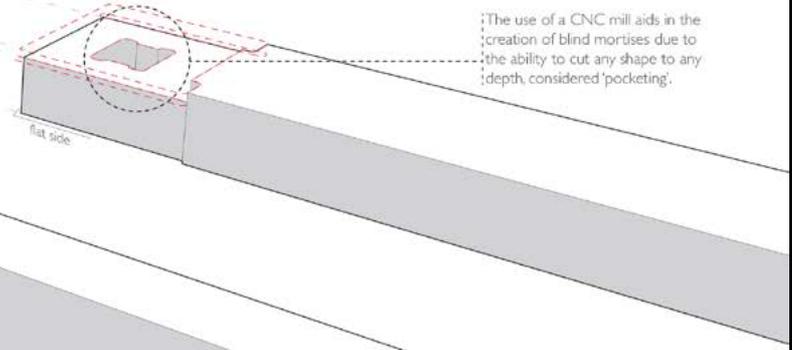
Can be applied as sheet to sheet, frame to frame, or sheet to frame



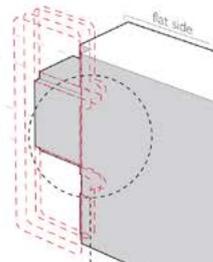
Due to the found nature of the pieces used in these explorations, every surface is considered rough and must be milled in order to ensure a tight fit.



The use of a CNC mill aids in the creation of blind mortises due to the ability to cut any shape to any depth, considered 'pocketing'.

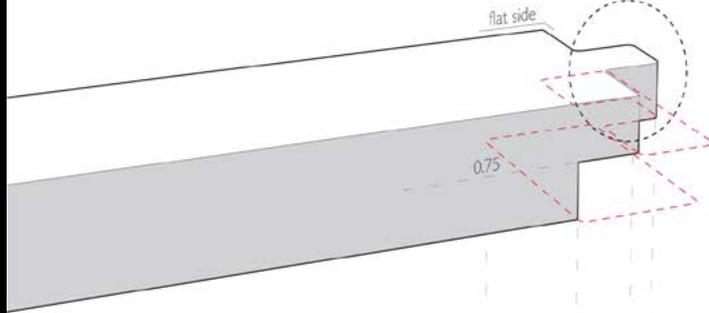


Seen in many of these joints, the extra bump outs are called 'dog bones' and are created in order to provide the additional allowance needed in order to fit square corners through filleted corners, which are the natural result of the CNC router machining process.

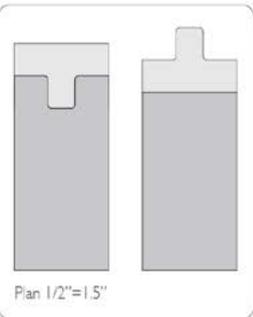
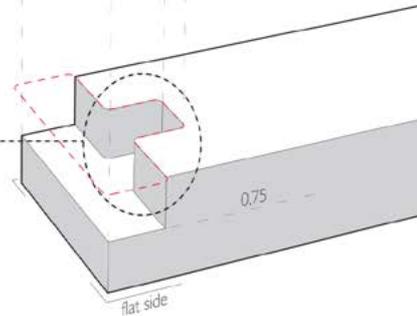


Stub Tenon Lap

One benefit of the stub tenon is the short length of the tenon, which requires less overlapping material and therefore helps to preserve as much of the original member's length as possible.



Because this detail is not a through cut but instead part of a lap joint, traditional methods of joinery (by hand or machine) would require considerably more time and set up. The CNC machining process on the other hand allows for this type of detail to be created with a negligible increase in the total amount time required.



In addition to the strengths of a lap joint, the stub tenon provides further resistance to tensile forces

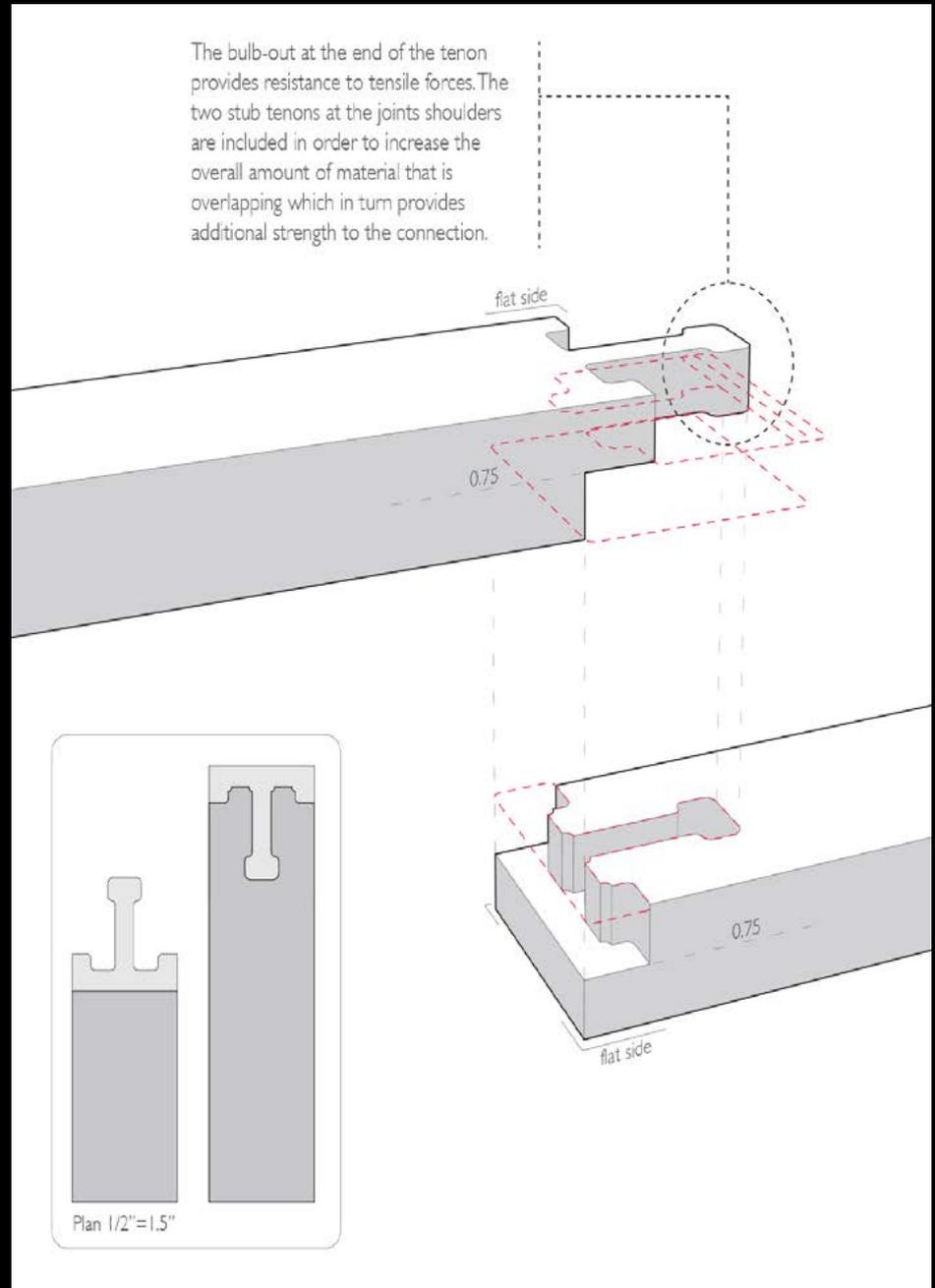
Can only be applied in frame to frame connections

Gooseneck Lap

Requires much more length of material to make than the Stub Tenon

Used for its strong tensile force resistance paired with its aesthetic appeal

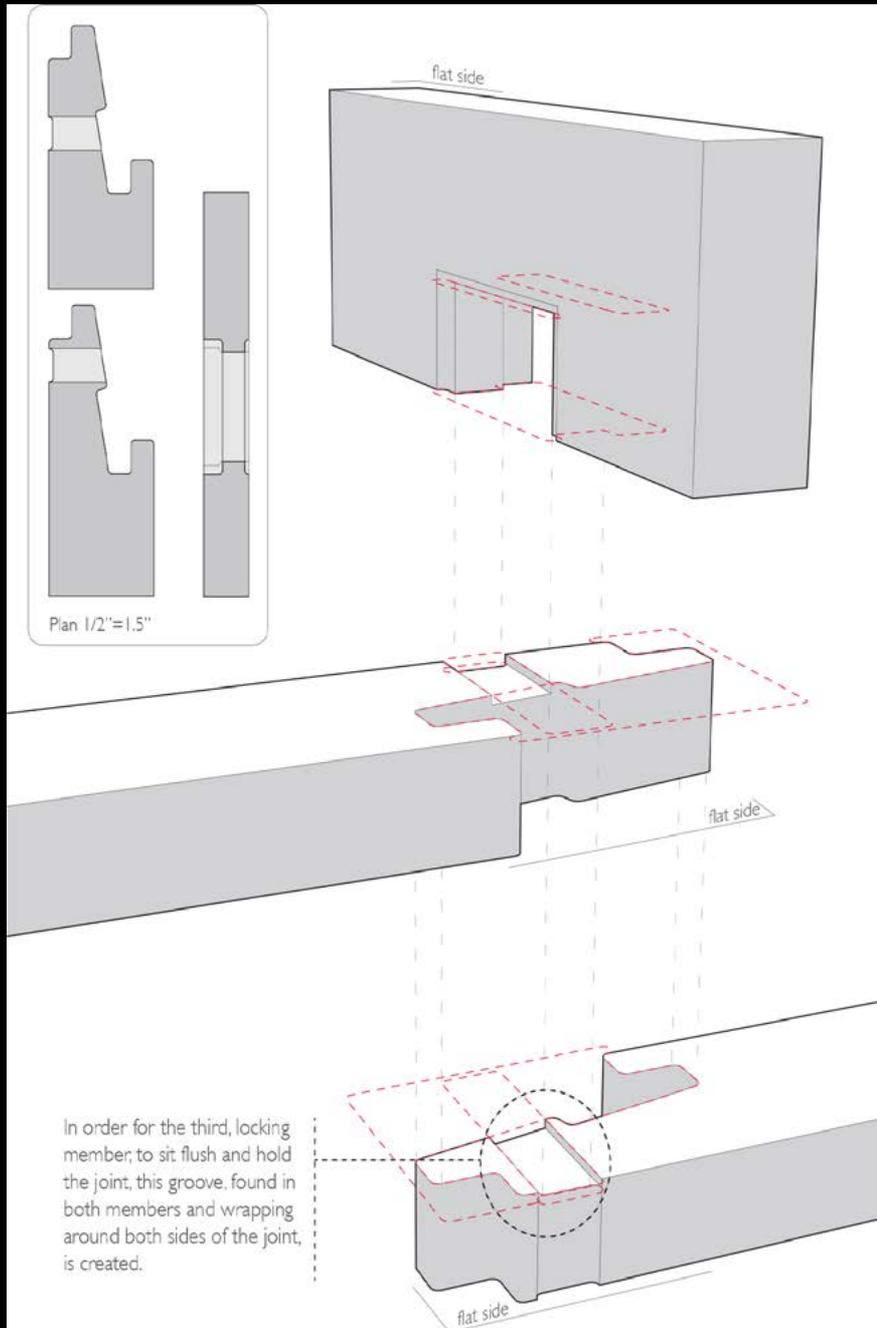
Can only be applied in frame to frame connections



Oblique Scarf

Requires most material but offers the highest strength due to the addition of a third member

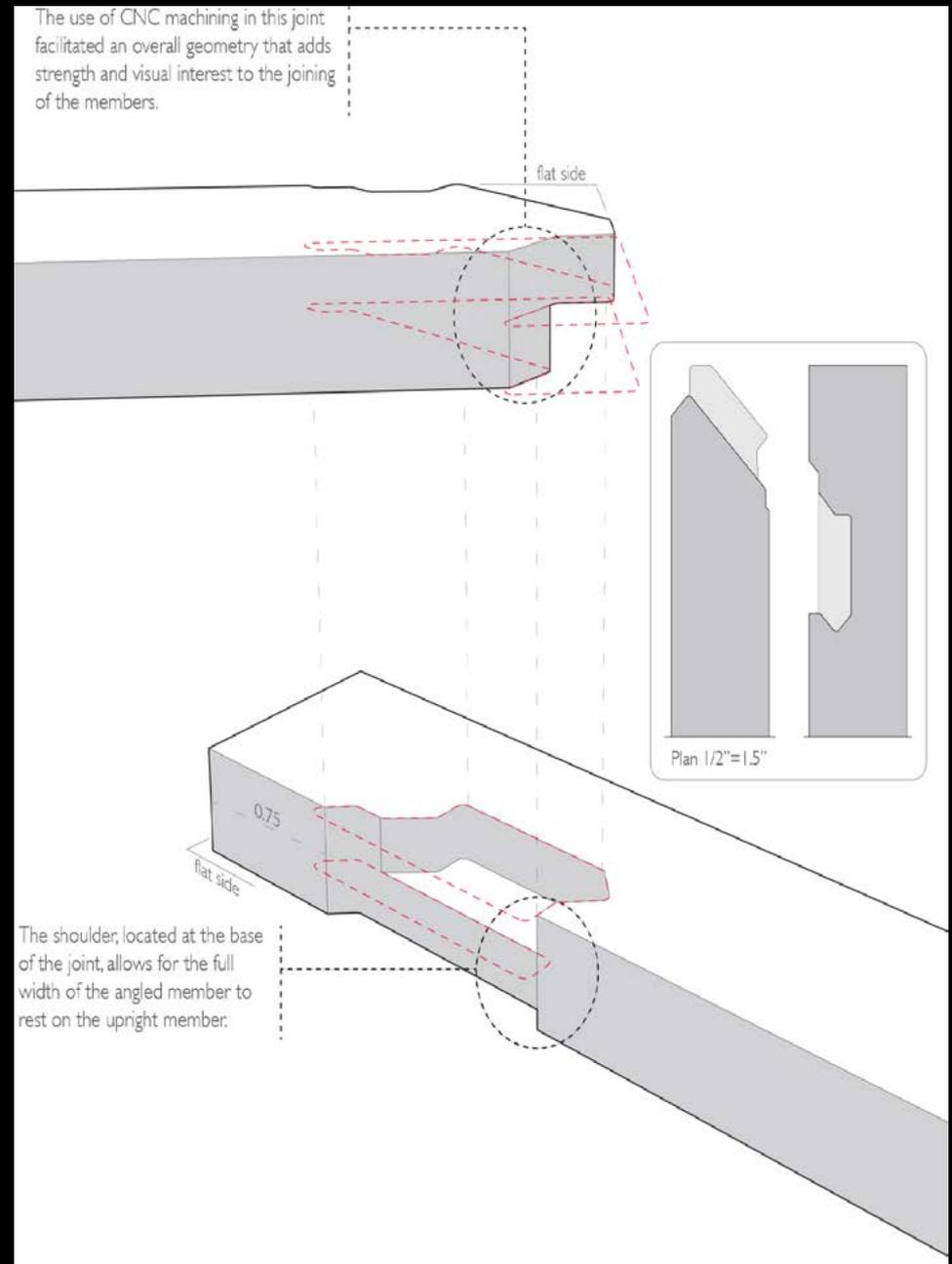
Can be applied in frame to frame or frame to sheet connections

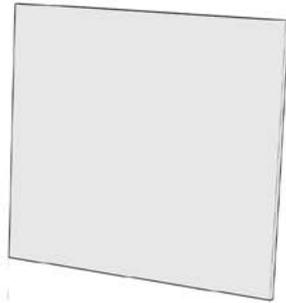
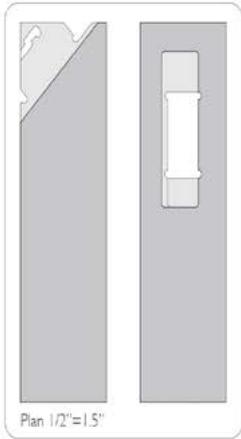


Notched Lap

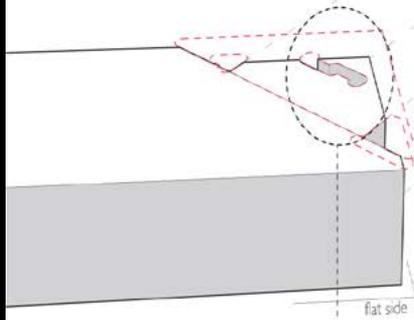
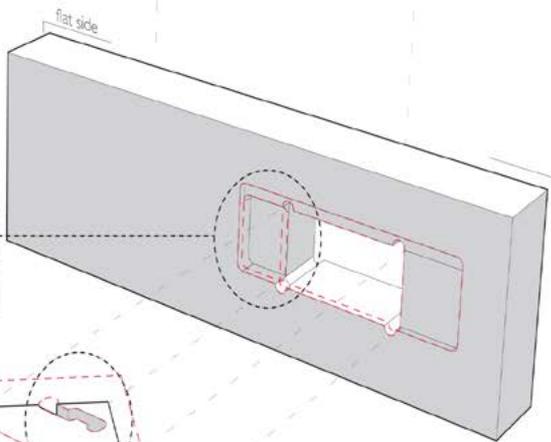
Can include many different variations, but provides for connections other than 90 degrees.

Can be applied in frame to frame or frame to sheet connections

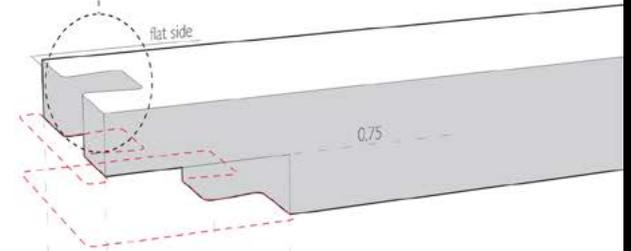




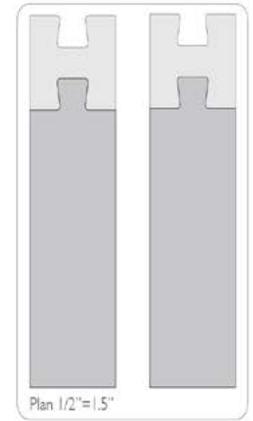
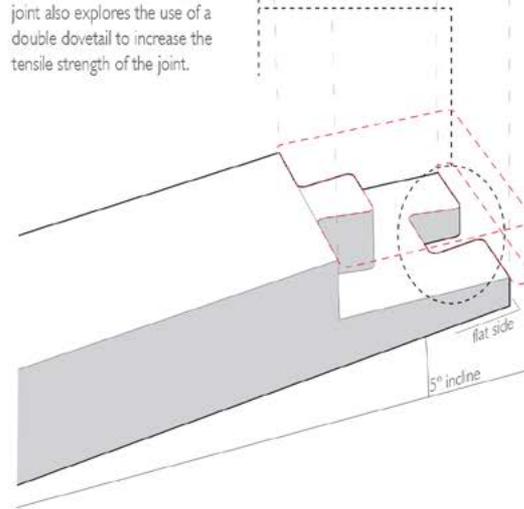
Similar to the mortis and tenon joints discussed earlier, this series of insets is incorporated in order to assure a flush and tight fit of the members.



Interestingly, both halves of this joint are identical, and it is the addition of the incline that gives the joint its additional usefulness.



In addition to the inclined plane, this joint also explores the use of a double dovetail to increase the tensile strength of the joint.



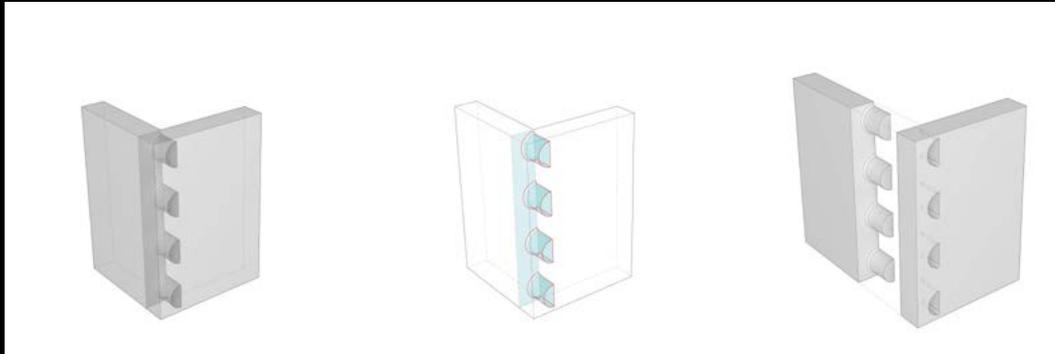
Effects of CNC on Design

Focus can be moved from the boundaries of individual pieces to where and how the pieces meet

Connection points become more important as the work becomes more about a system of parts than an overall form

Special attention must be directed towards the juxtaposition of perfection provided by the CNC machine and the inherent imperfections of materials

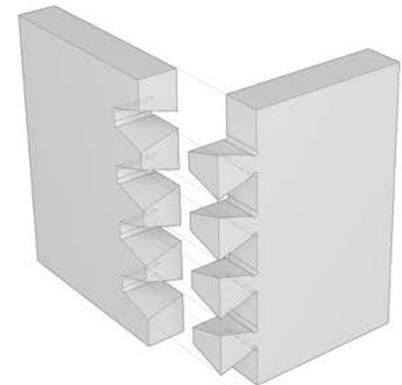
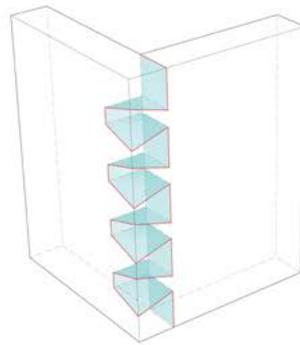
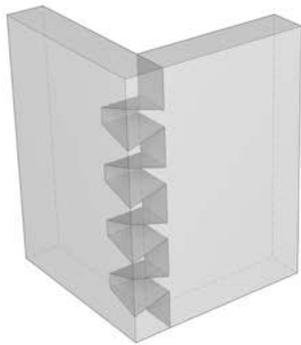
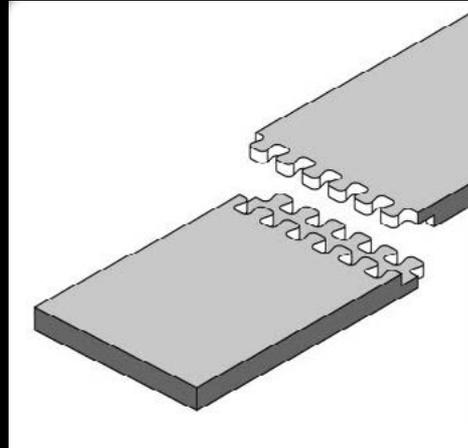
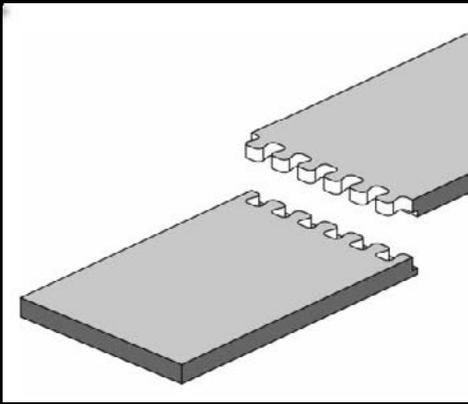
Two and Three Piece Planar Connections



Dovetail

Locks together fairly securely
even without adhesives

Easily scaled to any size joint

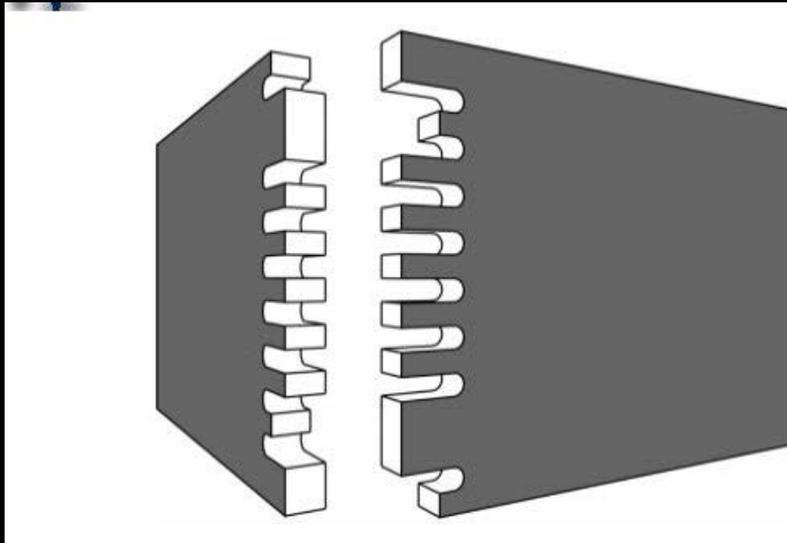


Finger

Another easily-scaled joint

Not as secure as dovetail

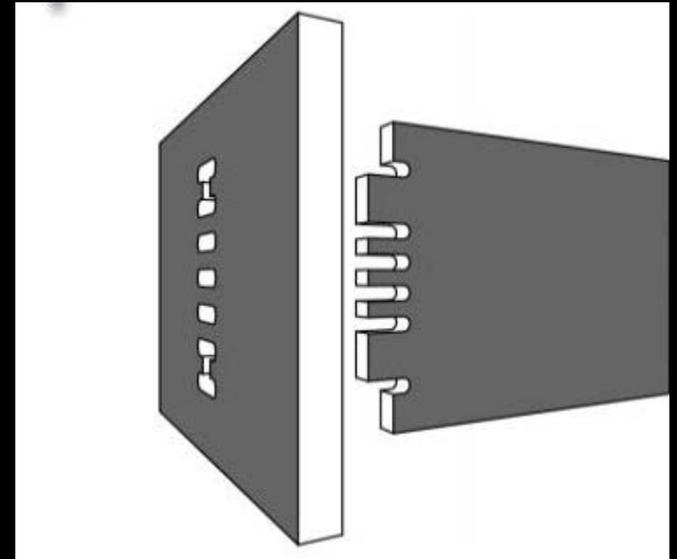
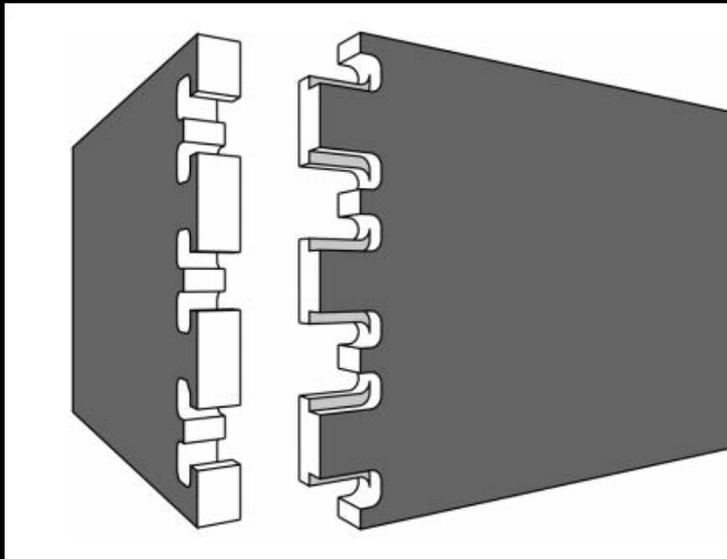
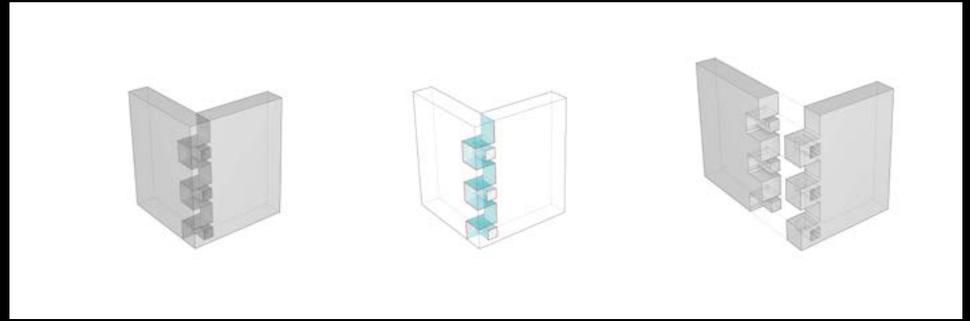
Much simpler than dovetail



Mortise and Tenon

Often mixed with finger joint

Secure in all directions except
the direction of insertion

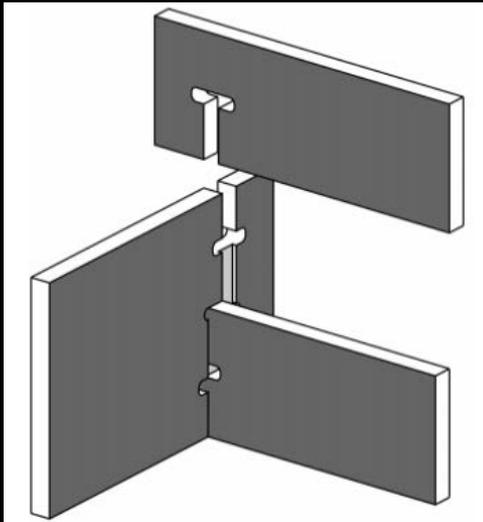
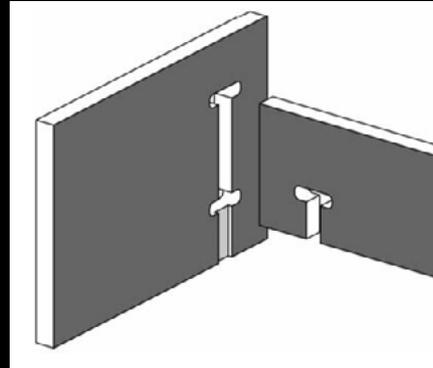
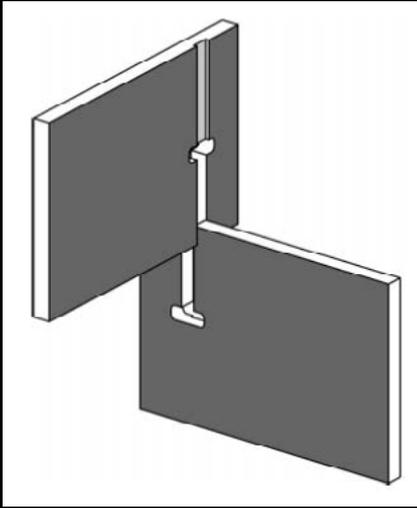


Slotted

Can not create a butt-joint

Good for joints in the middle of members

Not as strong against certain forces



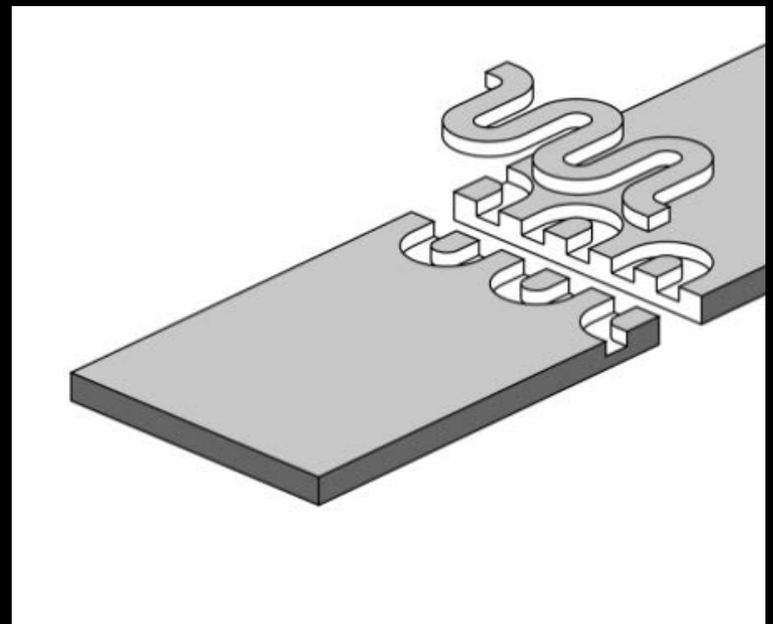
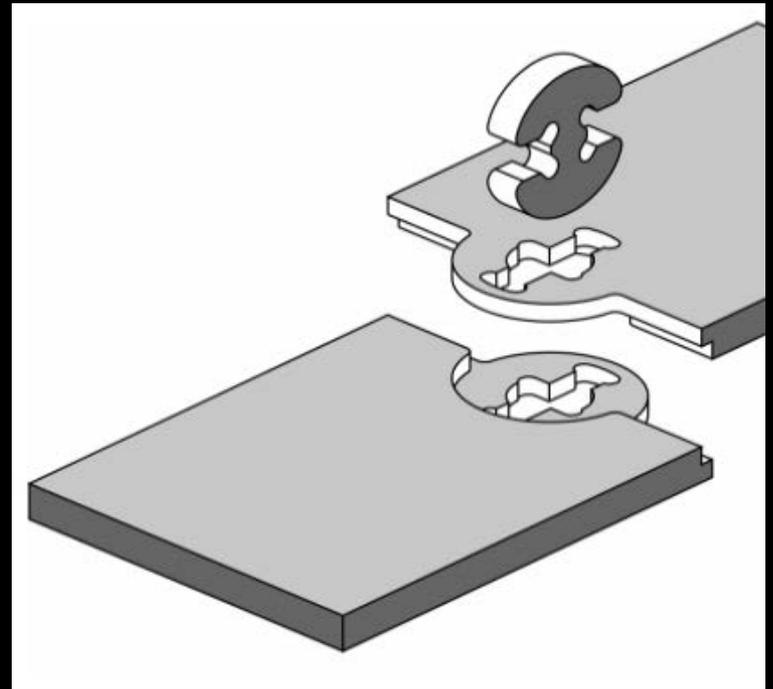
Keys

Can be used to join two boards in the same plane without losing any length

Not as strong

Can be made to be very aesthetically interesting

Can be mobile

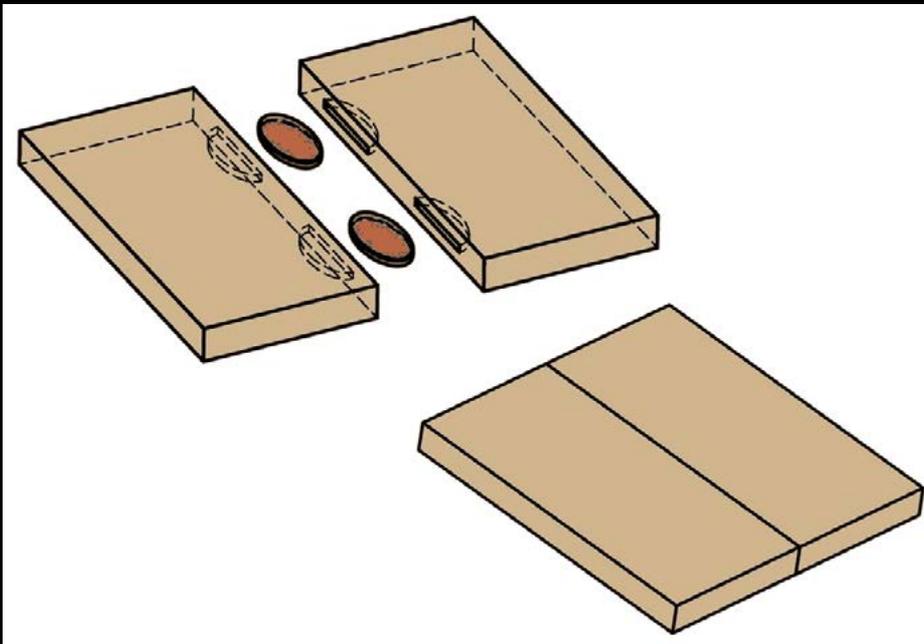


Biscuits

Like keys, but hidden

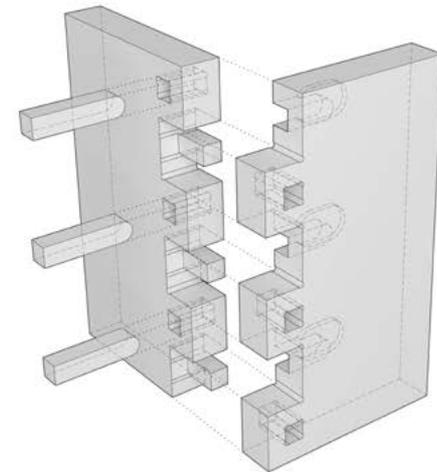
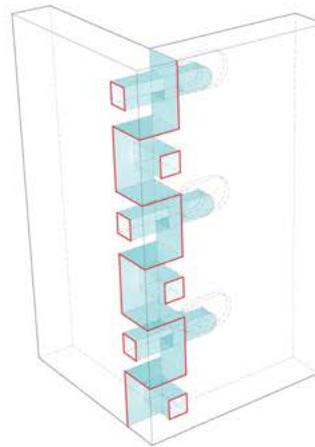
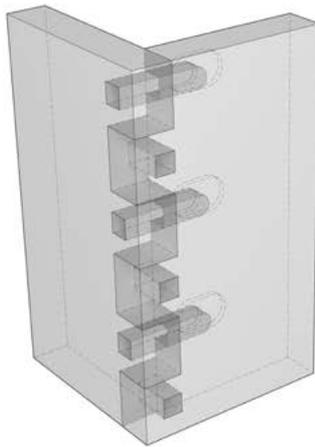
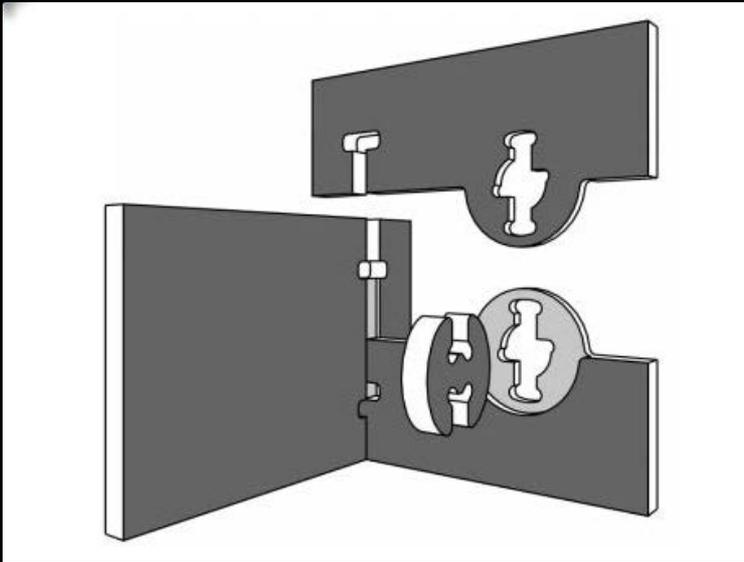
Can be used on any length of joint

No loss of useable length of material

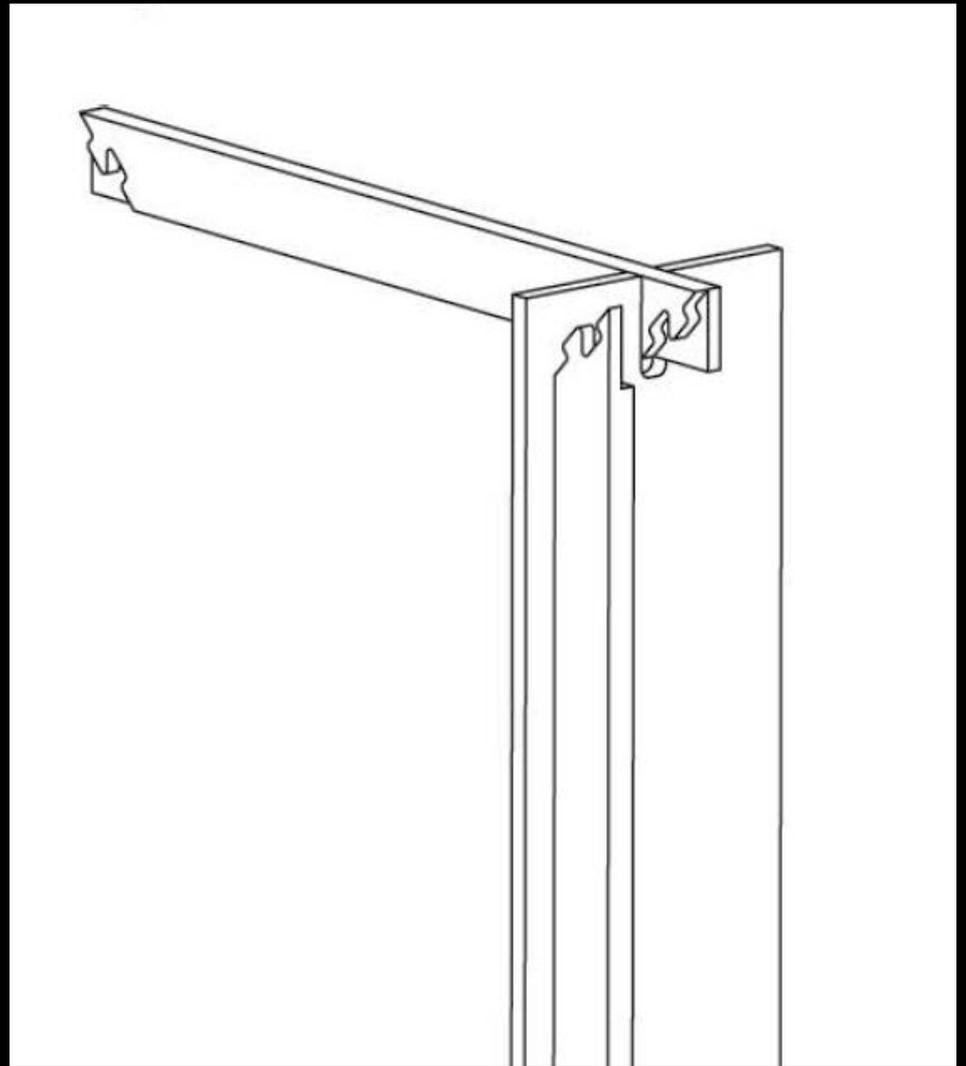
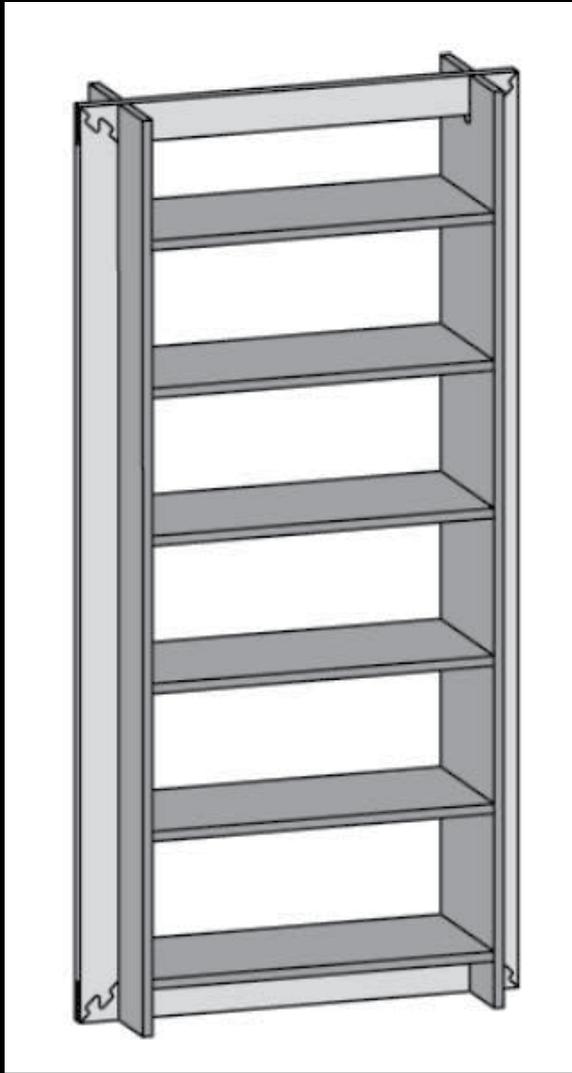


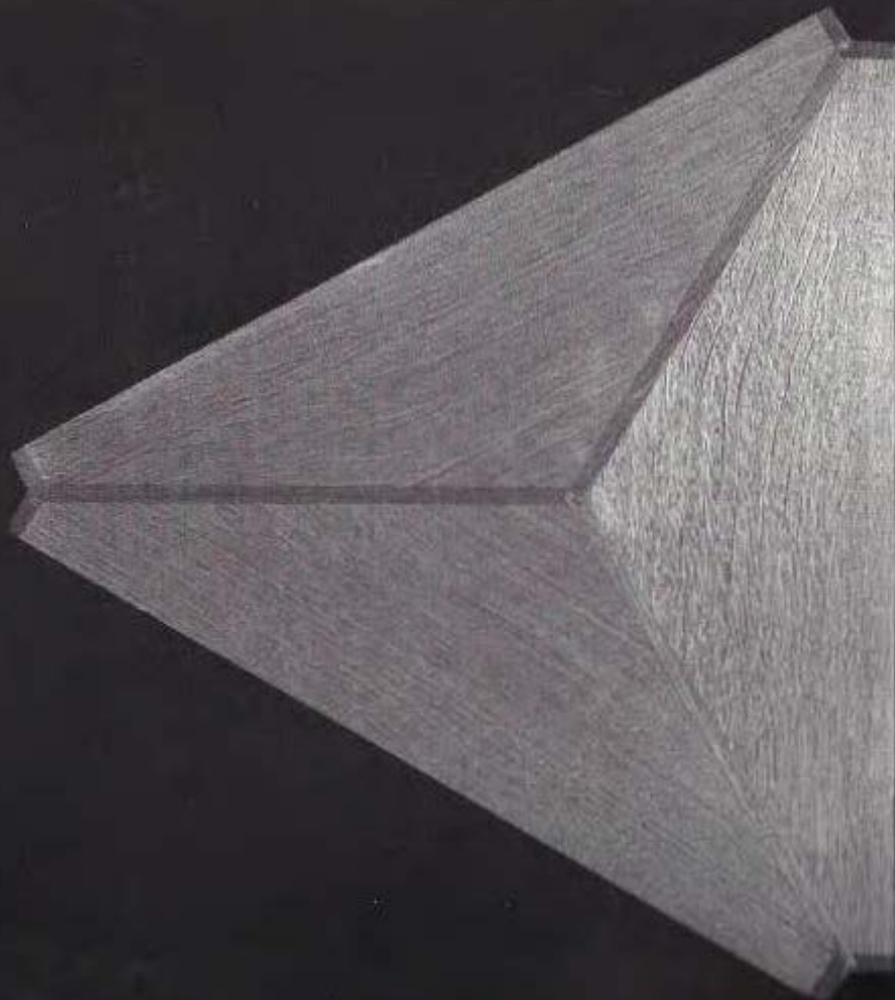
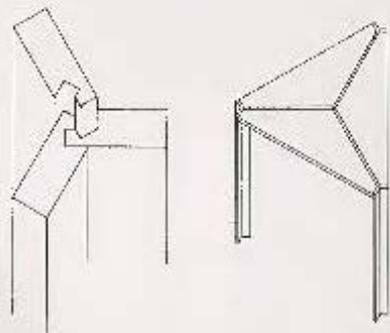
Combinations

Can take advantage of the strengths of multiple types of joint



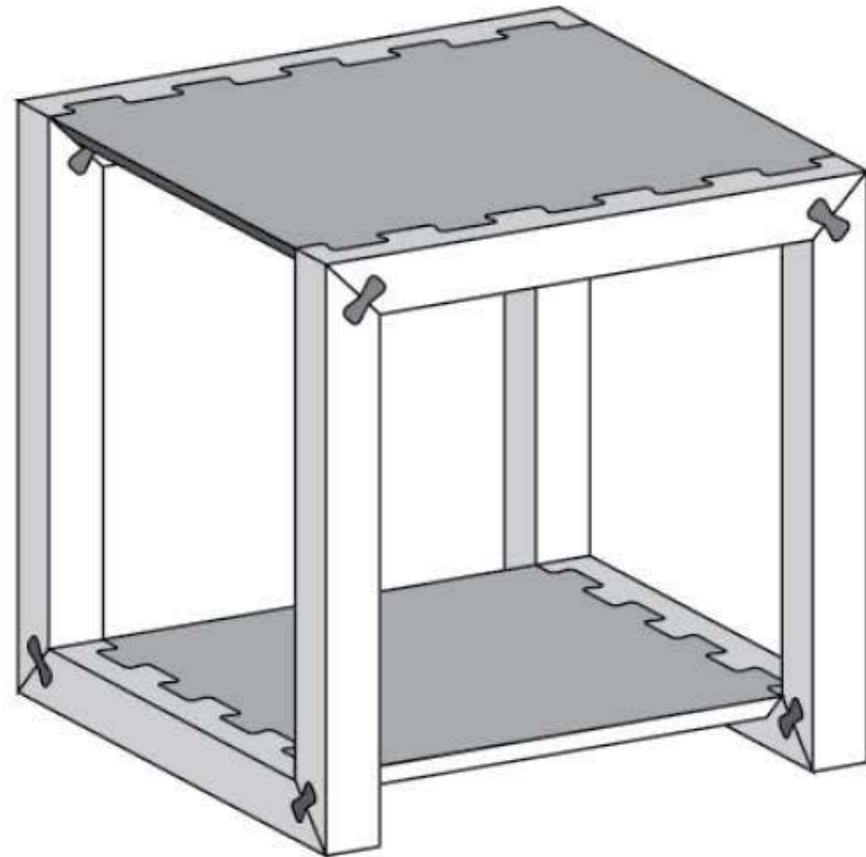
Combining Planar and Linear

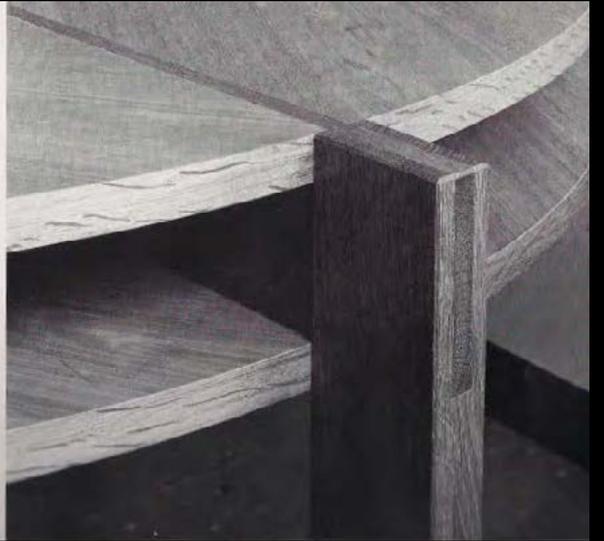
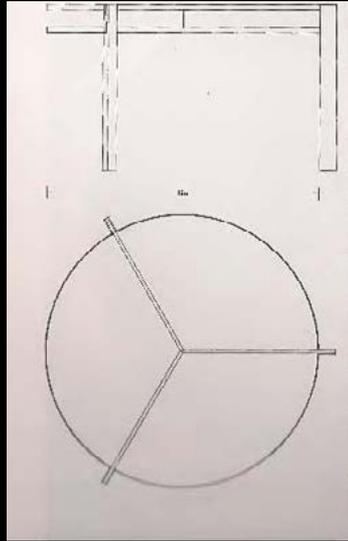
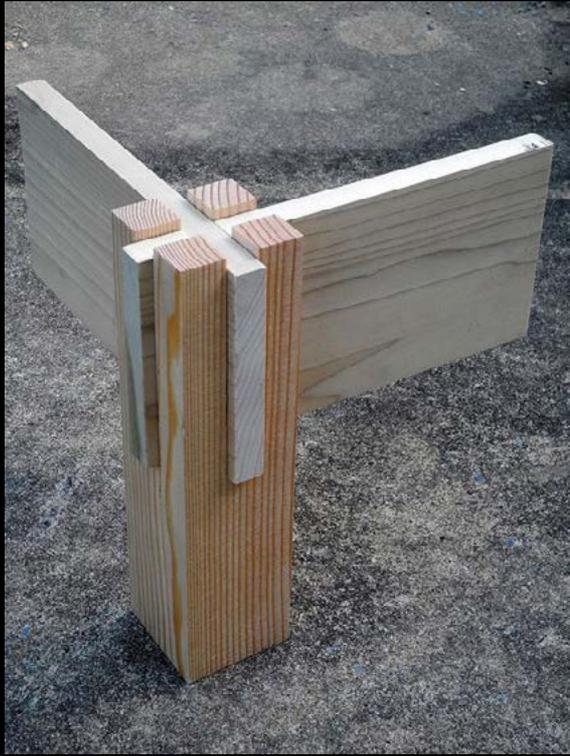




Side-Table

The side-table consists of an endless frame as well as of two shelves that are let in the frame. The individual solid wood parts of the framing timbers are joined at the corners with a Mitre Joint with Dovetail Key. The shelves are let in the framing timbers by means of modified Dovetail Tenons. Not only a rigid construction is thus created, but also, depending on the choice of material, a very attractive small piece of furniture.

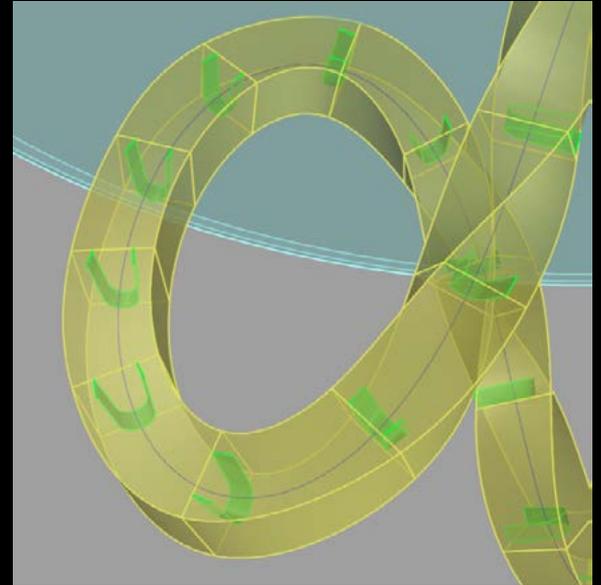




Finished Examples

Torus Knot Table

Dovetail joint detail is used to create a continuous curvilinear member





Finger Joint - Chair

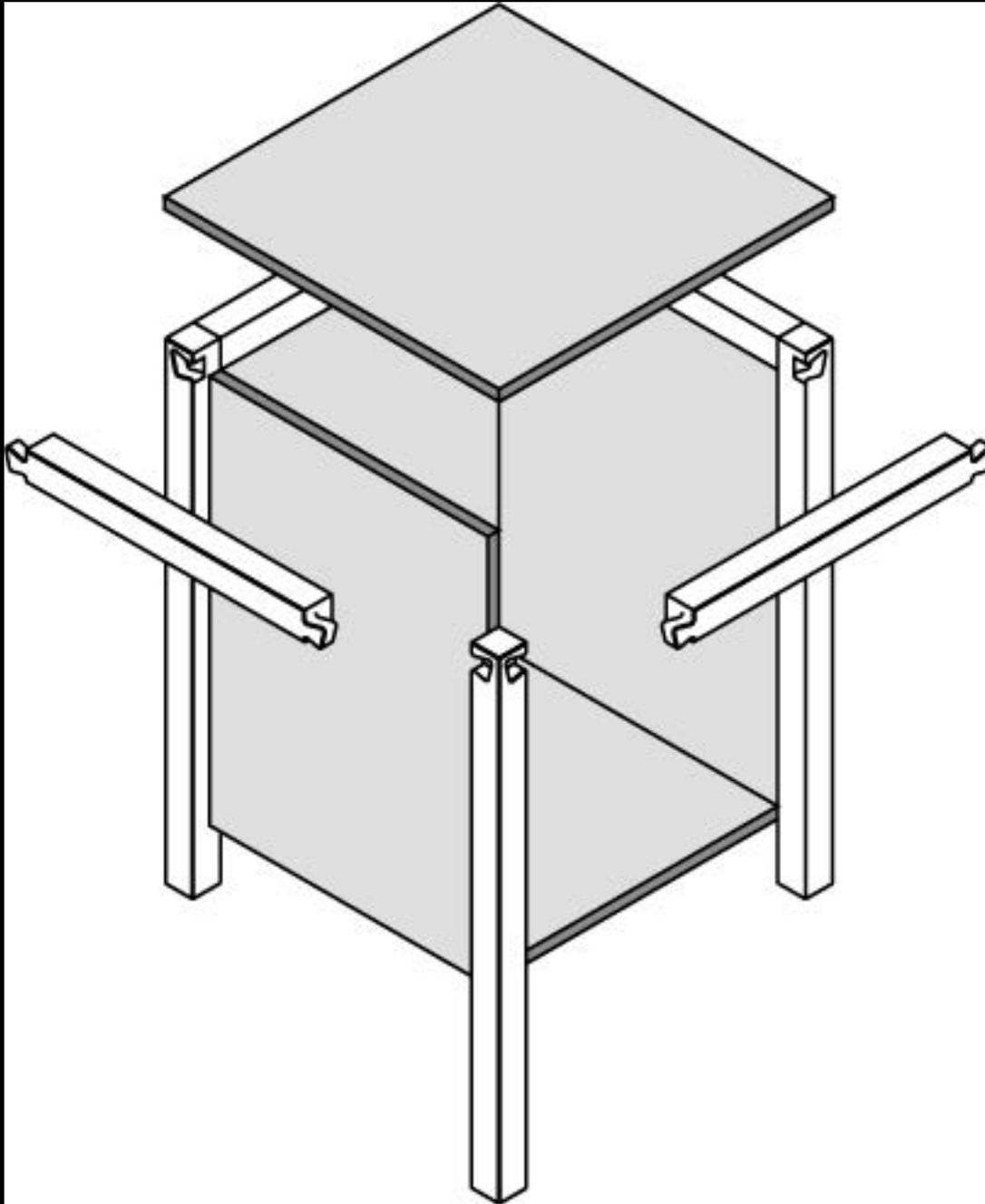
Finger joints clasp the next member, creating a strong connection while changing axis.



Kundera Chair - Paulo Neves & Alexandre Kumagai

The seat back provides the structure, holding the chair together by tenon joints





Upright Furniture

Linear members are joined using a halved dovetail corner joint, creating a U shape.

The sides are then pushed in using tongue joints on the sides of the linear

Self-supporting Framework

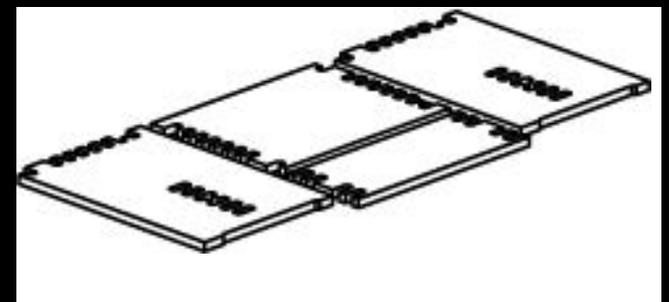
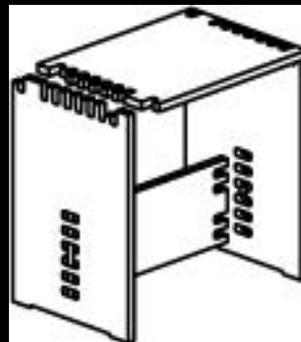
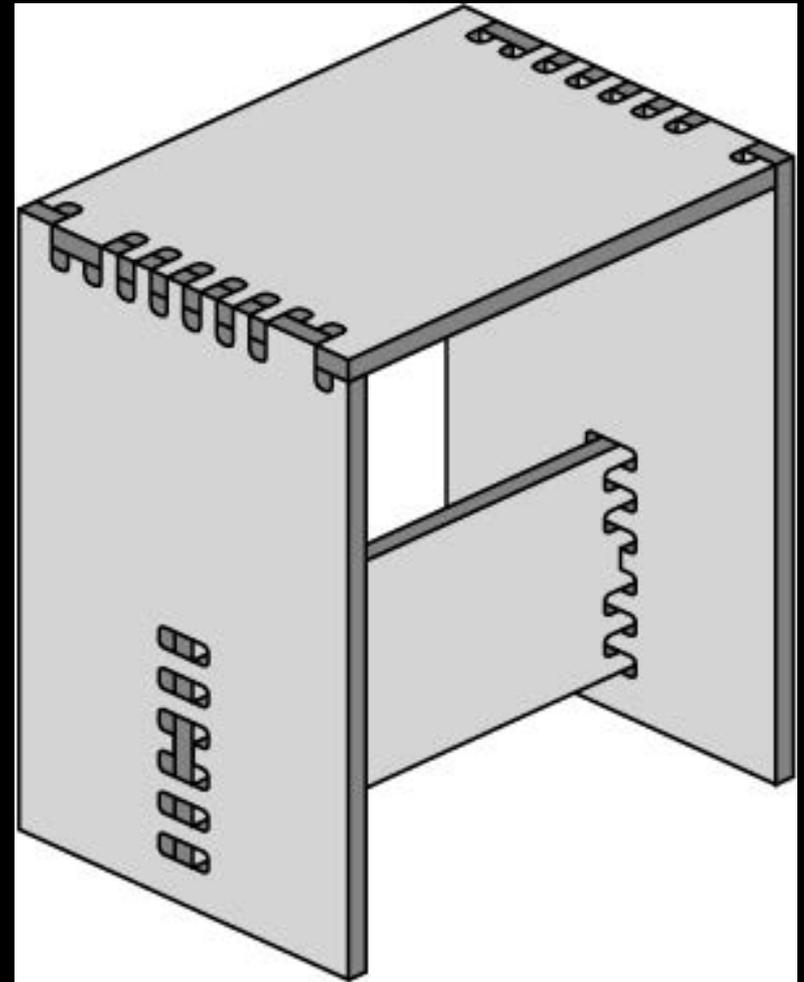
All the materials have the same profile, but each member is uniquely cut to support the abstract structure.



C...Stool - Jochen Gros

Made to clearly show the work done by the CNC as part of the aesthetic design.

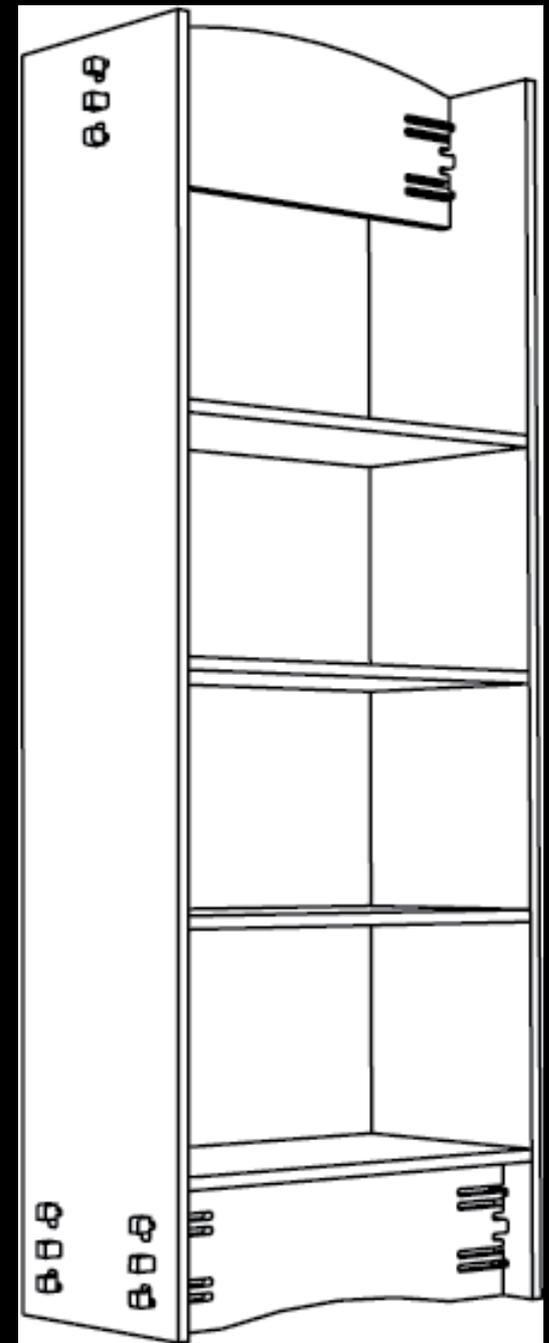
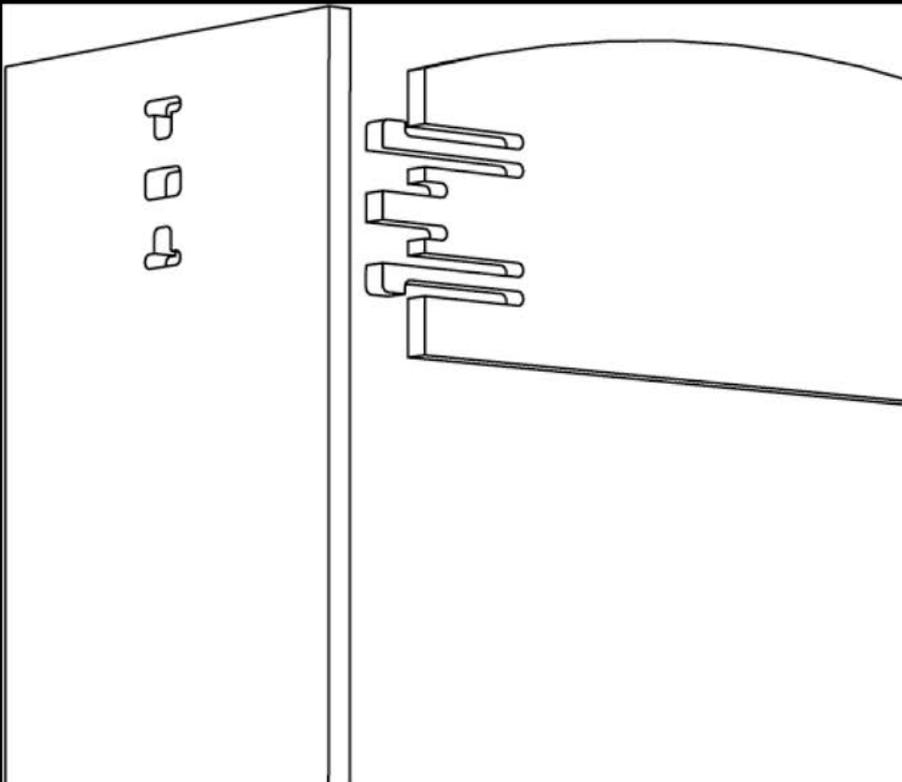
By exposing the Finger Tenons, the process of milling and joinery is made transparent

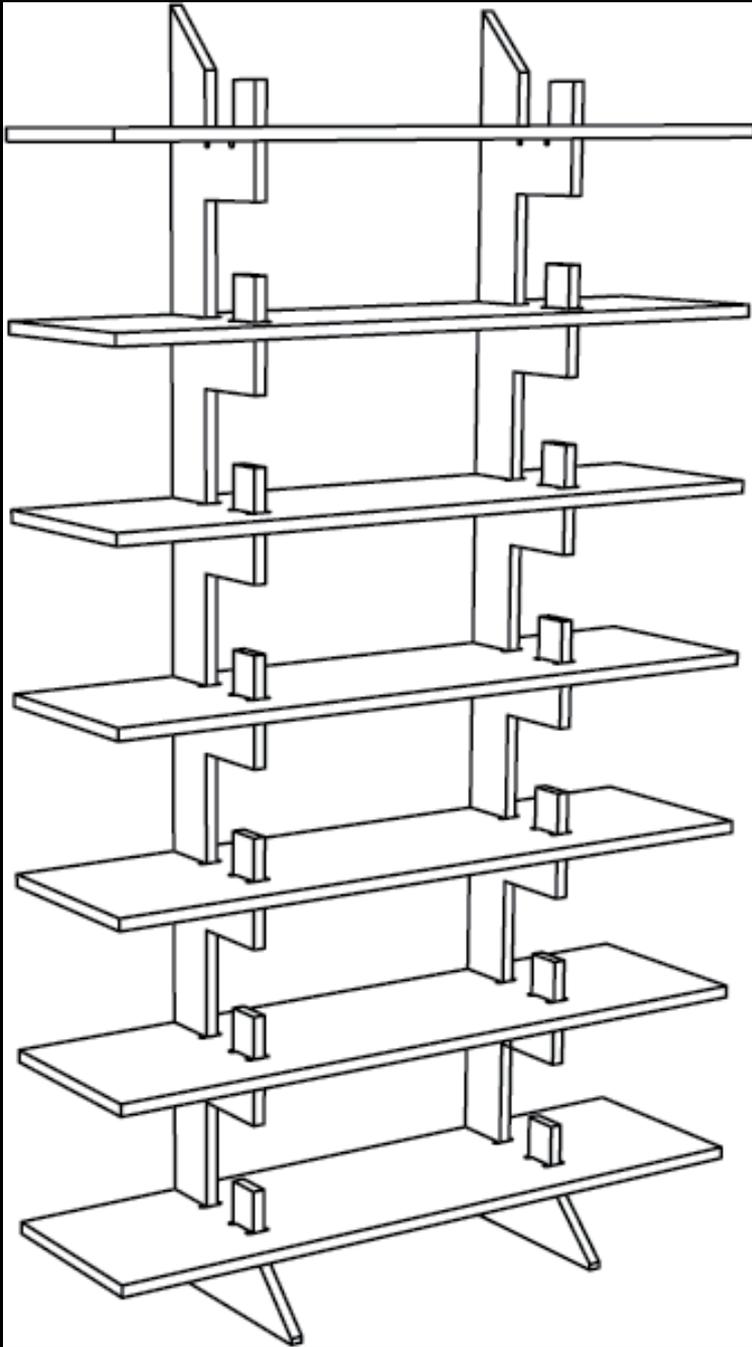


Clip Shelf

Crossbars are clipped onto the sides using a Clip Tenon Joint.

The shelves are mortises in the sides by means of Finger Tenons.

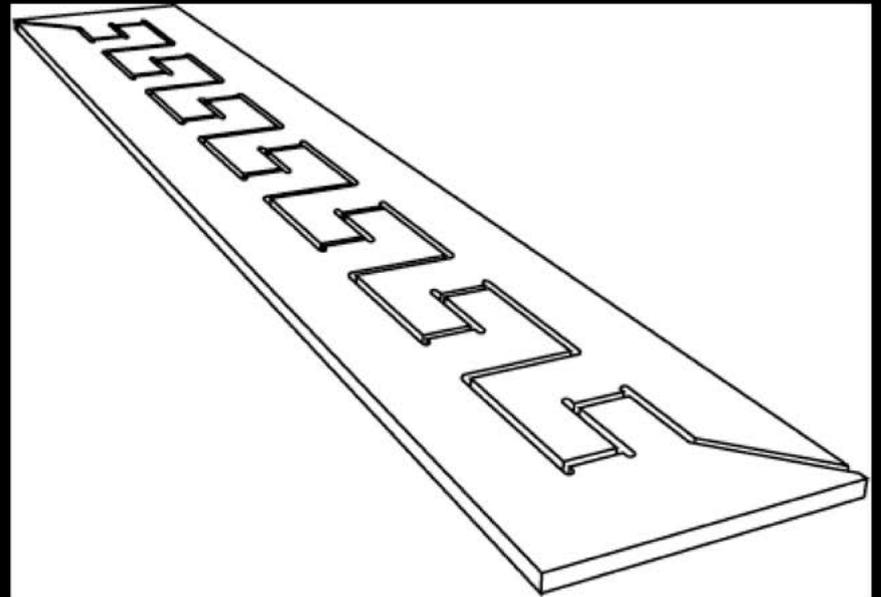




Meander Shelf

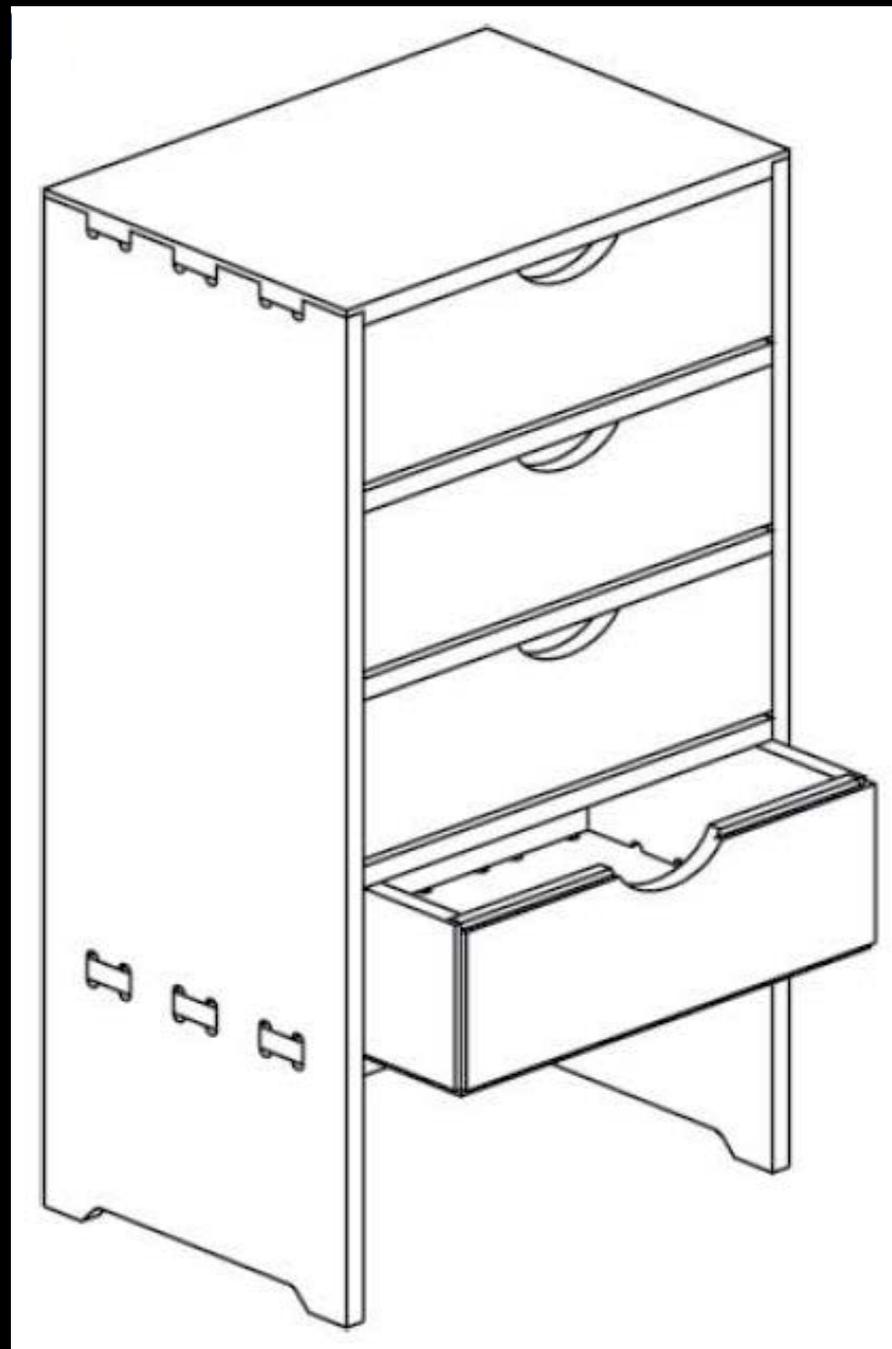
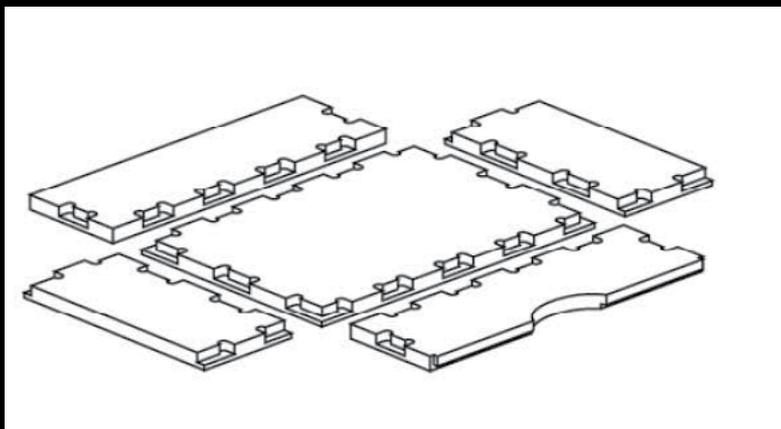
Designed as a simple shelf that would slot together without requiring tools, and still have the least amount of trim waste as possible.

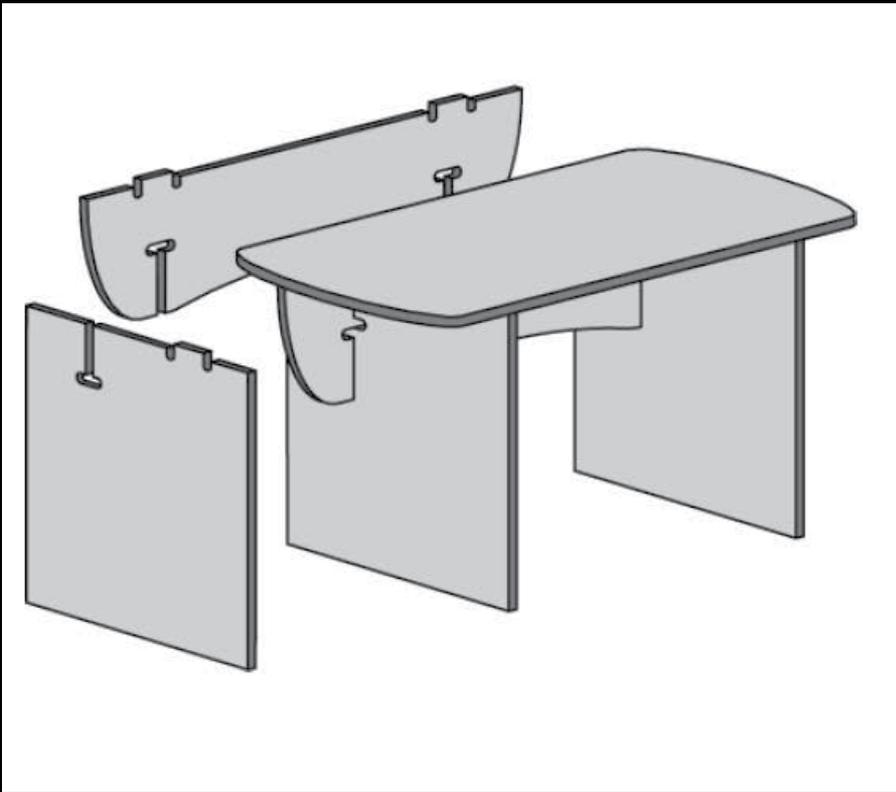
The two shelf bearers are shaped in such a way that they can both be produced from the same board by using Slotting Girder Joints as the interlocking shape.



Chest of Drawers

Top shelf and sides are joined by Lapped Finger Tenon Joints, while the bottom shelf is mortised through the sides by Finger Tenons.

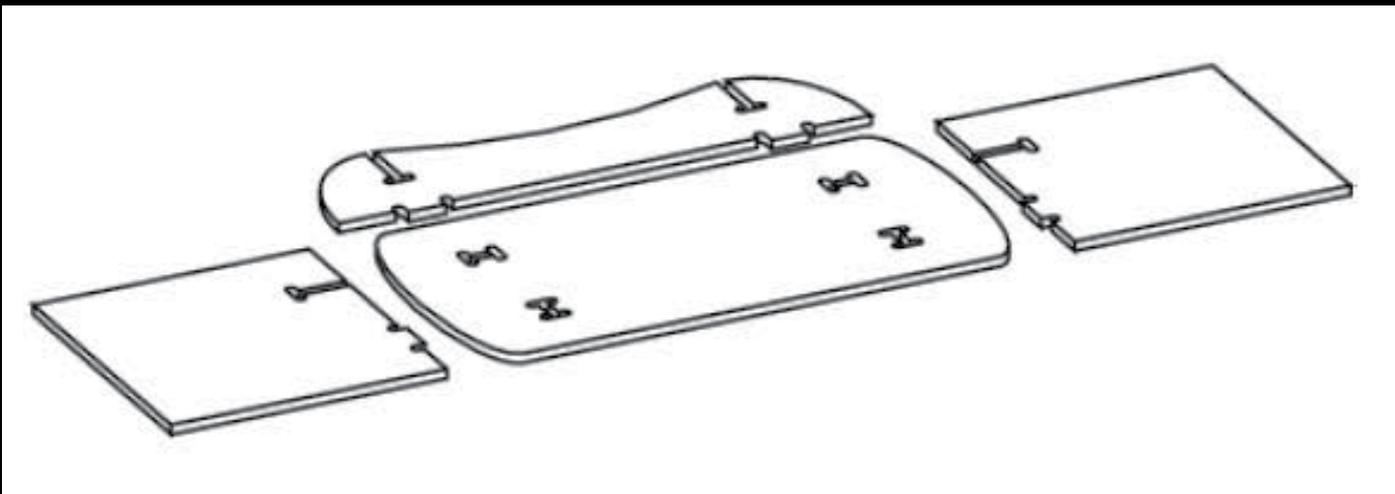




Simplizissimus-Table

Designed to be as a simple construction process, all the elements are machined together from the beginning.

The resulting pieces can be put together with no tools using Simple Setting Joints and Finger Tenons.



Joint Chair

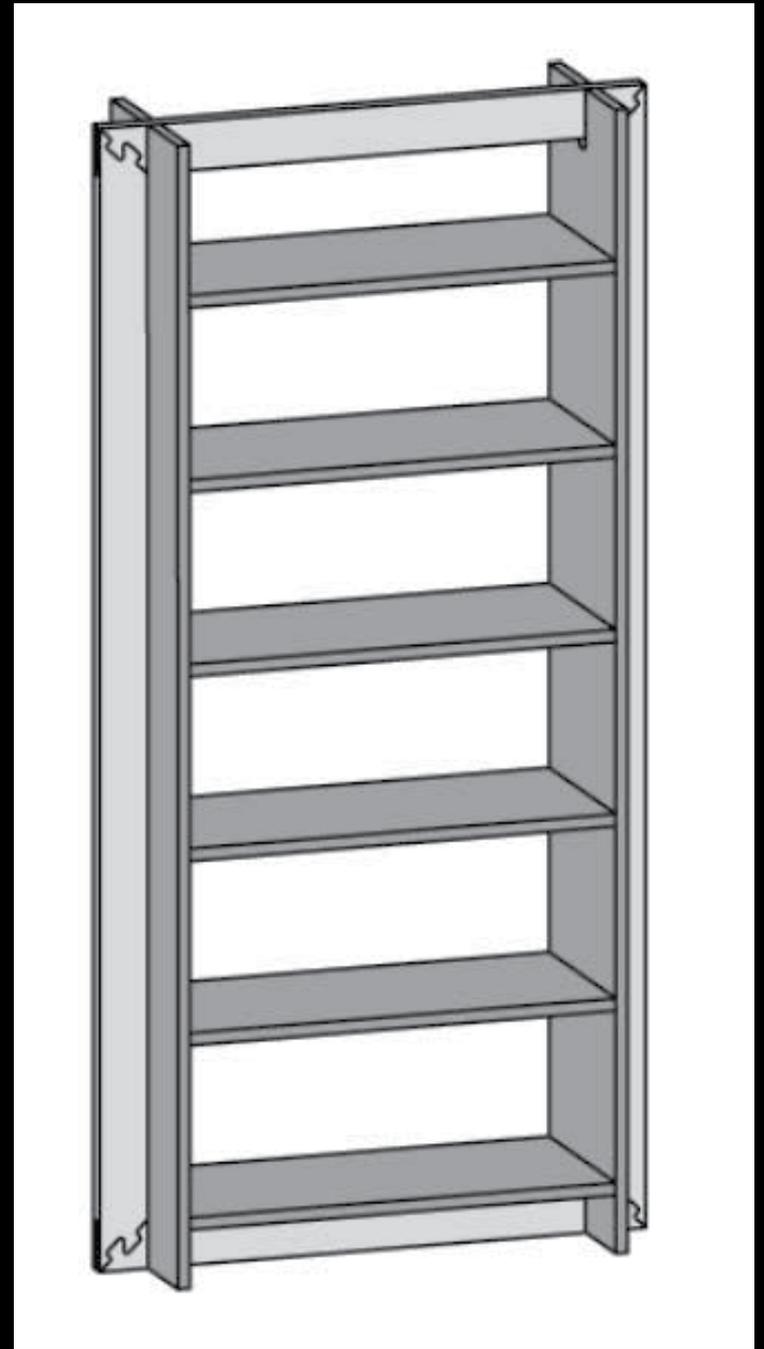
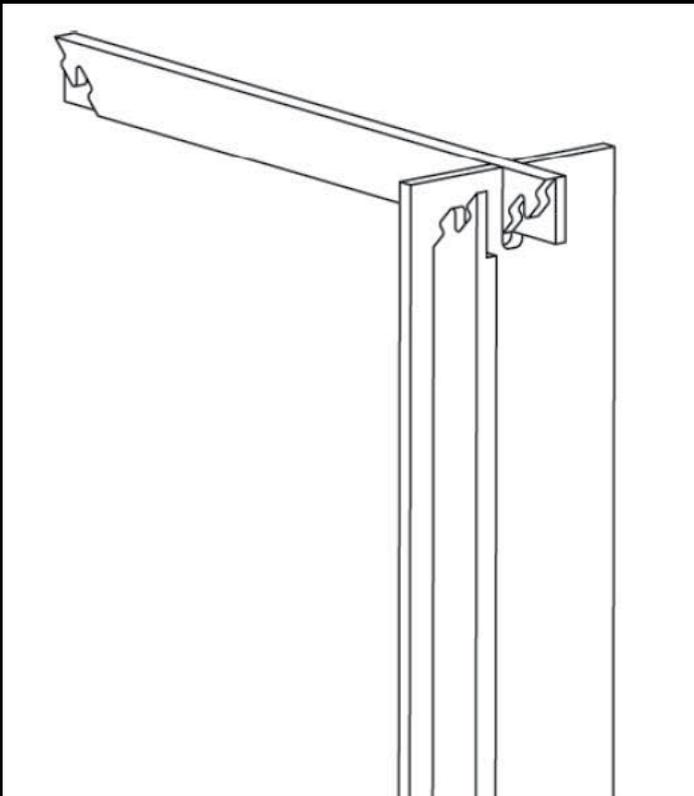


Sebastien Wierwinck Plywood Chair

Frame-Shelf

The wood sides and shelves are bound in place by the linear frame.

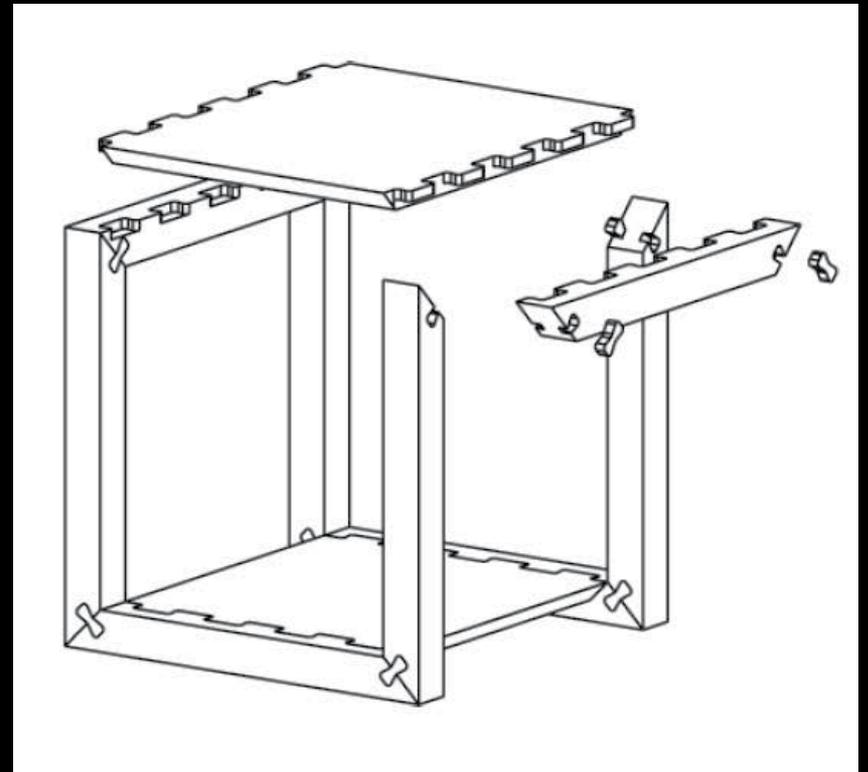
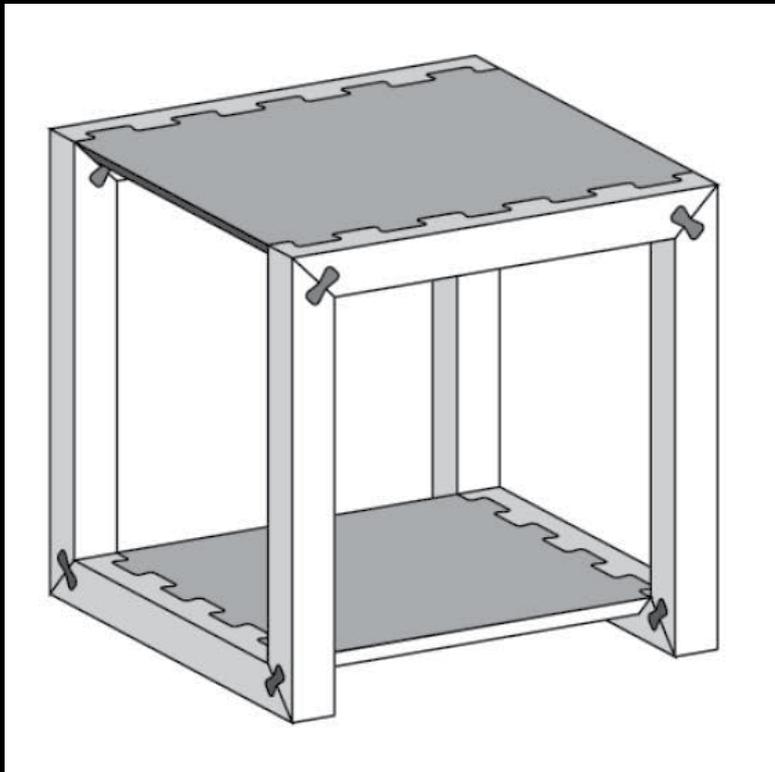
The frame members are held by Jigsaw Mitre Joints left exposed for decoration.



Side-Table

Wooden members form an infinite frame joined at the corners by Mitre Joints with a Dovetail Key.

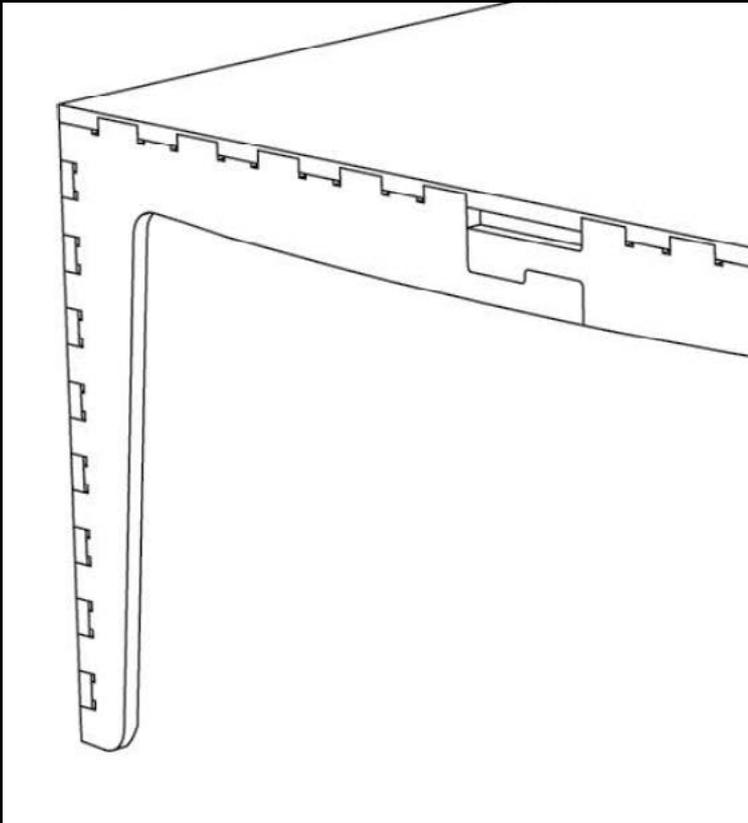
The shelves are added to the frame by Lapped Dovetail Tenons creating a pattern throughout the table edges



Zoom-Table

Designed to maintain a constant proportion between its length, width, and height; making the number of Lapped Finger Tenons remain the same no matter the size of the table.

The table joints on the side help prevent deflection of the tabletop when loaded.



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