Wooden Boatbuilding

Or

How to build strong, lightweight, streamlined shapes.
Joint Presentation

- Introduction to Wooden Boat Building (Jerry)
- Wooden Boat Building Methods (Tim)
- Building a Tortured Plywood Boat (Jerry)
- Plywood Lapstrake Boat Joinery (Jerry)
- Building a Stitch and Glue Boat (Nelson)
Wooden vs Fiberglass Boats

- Fiberglass Suitable for Mass Production and Cheaper
  - Often Two Molds: Hull and Deck/Cabin
  - Attach and/or Bond the Deck/Cabin to the Hull
- Wooden Hull Shapes Not Constrained by a Mold
- Wooden Hulls Can Have Better Strength to Weight Ratio
Graham Byrnes’ Outer Banks 20
Example of Sheet Plywood Bottom and Ashcroft Sides
Howard Rice’s Southern Cross
Explored Tierra del Fuego in a Modified 12 foot SCAMP

- Survived Rare 70 knot Cyclonic Winds
- Kelp Blocked Two Safe Anchorages
- Abandoned Boat and Swam Ashore
- Rescued by Chilean Patrol Boat
- Southern Cross Rescued 3/5/2017

Form Follows Function

- How a Boat is Used influences Hull Shape
- Hull Shape Influences Building Methods
  - Monohulls
    - Displacement
    - Planing
    - Semi-Displacement
  - Multihulls
    - Catamaran
    - Trimaran
Displacement Hull

- Held Up By Buoyancy, i.e, Static Force
- Not Designed to Exceed Displacement Speed
- Characterized by a Curved Underwater Surface
- Minimize Bow and Stern Waves for Efficiency
Displacement Hull Speed

hull speed (knots) = 1.34 x square root of length at waterline (ft)
Planing Hull

- Add Hydrodynamic Force
- Characterized by Flat Underwater Surfaces
- Sufficient HP to Overcome Resistance of Bow Wave
- Straight Keel to the Transom
Semi-Displacement Hull

- Can Be Pushed Beyond Hull Speed
- Characterized by Flat Underwater Surfaces
- Keel Curves Up to the Transom
Multihulls

- Catamaran
  - Two Narrow Hulls
  - Each Hull Can Float the Boat (You Can Fly a Hull)
- Trimaran, i.e., A Three Hull Boat
  - Center Hull (Main Hull or Vaka)
  - Outrigger Hulls (Floats or Ama)
  - Typically a Float or Ama Cannot Float the Boat
Blanchard Jr. Knockabout (Hull No. 7)
Seattle, Washington

TABLE OF OFFSETS

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Notes:
- Measurements were taken using a laser "Total Station" and developed in AutoCAD software.
- Distances are in feet, 0.04" = 1'-0".
- Waterline offsets: 1'-0".

Scale: 1'-0" = 1'-0"
Lofting from Table of Offsets
You Can Get Up Off Your Knees
No Lofting Required

• Dimensioned Drawings
• Full Size Patterns
• CNC Kits
Be Prepared to Work in Metric

- Marine Plywood is Metric
- Many Boatbuilding Plans are Metric
- Only Liberia, Myanmar and the USA Haven’t Adopted the Metric System

**WE AMERICANS REJECT YOUR ROYALTY’S LAWS, TAXES, SPELLING AND TEA**

**BUT WILL NEVER REJECT KING HENRY’S FOOT AS A UNIT OF MEASUREMENT**
Wooden Boat Building Methods (Tim)
Desired Hull Shape with Little or No Limitations
Cold-Mold

Hull is built up in layers of veneer. Hull can be built over a mold to create a light-weight and accurate hull rivaling most all modern constructions.
Each layer of veneer is epoxied to the layer below. Each layer is placed on alternating diagonals. When one layer has cured, another layer is added. Layers are held in place with staples to hold alignment while curing. Far fewer staples are needed if a vacuum bag is added.
Cold-Mold

In addition to using a mold, cold molding can be built over other types of construction.
Of course if you have a lot of time and friends:
The toughest and heaviest of constructions. With some work they can be repaired to extend their life. The most complicated shapes can be made. Used on military and work ships that traveled the world; yet can be used on the smallest of boats too.
Carvel

Built over heavy frames that were usually sawn to shape. Frames must not only fit the hull curvature but will need to be beveled to get contact with planks. Planks are typically fastened to frames with screws. Thick planks need to be hollowed on the inner face to make contact at the frames. They also need a bevel between planks to allow space for cotton caulk.
Planks are added with clamps and fastened as each plank is fitted. Making patterns, shaping and test fitting planks will be the most time consuming part of making the boat. The number of clamps can limit you.
Carvel

Making a pattern for the end of a simple plank. Some planks will require extensive templating and shaping.
Fastening the plank shaped from the pattern. Screws are countersunk and plugged. Cotton caulking is driven between planks to make watertight.
Final results for a long lasting work boat.
Strip planking uses thin strips glued to each other. They were traditionally nailed to each other but now are most likely glued with epoxy or resorcinol. Aliphatic can be used if you will be covering the final hull with fiberglass.
Strips need to make good contact at the glue line. Strips need to be beveled and twisted to make contact. As an alternate and to shorten the fitting time, the edges can be routed with a bead and a matching cove.
Strip Planking

Example of the form for building. The ribs were laminated over each section of the mold before the mold was erected. Note that the ribs will stay inside the hull when finished.
Alternate technique to work with strips. These forms will be removed entirely at the conclusion. Note that the transom and keel will stay with the hull.
Strip Planking

A beautiful example of this technique. Note there are no ribs. It is a pure monocoque construction.
Once again, if you have a few friends to help.
Approximation of Desired Hull Shape
Constant Camber

Constant Camber uses the same technique as Cold Mold, but pre-laminates the plies on a uniformly curved mold to create curved plywood.
Veneers are forced down on a curved form with a vacuum bag to make plywood.
Here you see a large sheet of custom molded plywood which is one section of the boat’s hull. The diagram shows a hull with three sections.
Some almost finished hulls for a catamaran. Note these still need a transom added before the deck is built.
Chris White’s 52ft ‘Juniper’ hulls built with Constant Camber System.
Approximation of Desired Hull Shape
Clinker/Lapstrake

Lapstrake uses thin planks that overlap and are fastened to each other with screws or rivets. The frames can be fastened to the planks or left out for a smoother interior.
Approximation of Desired Hull Shape
Clinker/Lapstrake

A picture of a boat with copper rivets holding the ribs to the lapstrake planking. The ribs can be either laminated or steam bent and were part of the form as the boat was built.
One way to build is to use plywood forms with wood stringers that show where the planks will overlap. When the planks are fastened to each other they can also be fastened to the stringers to strengthen the joint if desired.
Lapstrake makes a beautiful traditional boat shape.
Approximation of Desired Hull Shape
Glued Plywood Lapstrake

A variation of lapstrake using plywood. This allows for fewer wider planks, retaining the traditional look.
Plywood can be fastened to stringers over forms. Forms can be temporary or become bulkheads for the finished boat. This boat appears to be using them for bulkheads.
Hulls with complex compound shapes may require using double layers of half thickness plywood where full thickness is too stiff to conform. Strips of plywood are fastened to the stringers, then a second offset layer is laminated over the joint.
Marine plywood is cut to a pattern that will pull into the hull shape when formed. This partial hull has used plastic cable ties to pull the pieces together. A more common method is to use copper wire as a twist tie.
The separate pieces are pulled together in stages and the full shape develops. When each seam is ready, fiberglass tape is epoxied along the seam on the inside.
Sheet Plywood Stitch-and-Glue

When the complete boat construction is done, it is covered with fiberglass cloth and epoxy.
Hull Shape Limited by Materials
Tortured Plywood

Jerry will talk about this method later.
Building a Tortured Plywood Boat (Jerry)

Wooden Boat Joinery (Jerry)
Tortured Plywood
Glen-L’s La Chatte
Tortured Plywood
Glen-L’s La Chatte
Flat Bottom and Plywood Lapstrake Sides
John Welsford’s Pathfinder
Maybe a Rocker is a Better Old Man’s Project
Plywood Lapstrake
Arch Davis’ Penobscot 13 with Stringers Remaining in Boat
Plywood Lapstrake
Iain Oughtred’s Arctic Tern with Stringers Removed
Plywood Lapstrake
Shop Made Deep Clamps
Joinery
Scarf Joint to Extend Length
Joinery
Gain at Bow to Change from Overlap to Flush
Bird's Mouth Spar Calculator

Figure 1 - Bird's Mouth Spar: Definitions

- **O.D.** is the outside diameter
- **I.D.** is the largest inside diameter
- **R₁** is the shortest inner radius
- **R₂** is the largest inner radius or half **I.D.**
- **N** is the number of sides (eight in this case)
- **α** (alpha) is the angle between adjacent staves or **360° / N**
- **L** is the width of material
- **H** is the thickness of material

**Important Ratios**

- **K** is the thickness to width ratio of staves or (**H / L**)
- **M** is the "conversion factor" or (**O.D. / L**)
- **A** is the inside to outside diameter ratio or (**I.D. / O.D.**)
# Bird’s Mouth Mast Calculator for Tapered Mast

## Calculator 4: Given N, O.D. and H, calculate L, I.D. and K

### Inputs

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## Calculator 4: Given N, O.D. and H, calculate L, I.D. and K

### Inputs

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### Status:


Bird’s Mouth Mast
Eight Sides with Exaggerated Taper
Bird’s Mouth Mast
Glue Up with Cable Ties for Clamps
Bird’s Mouth Mast
Building Method

• Scarf Staves to Length of Mast
• Cut Staves with Bird’s Mouth on One Edge
• Taper Edge Opposite Bird’s Mouth for Tapered Mast
• Epoxy Staves Together with a Slow Hardener
• Up to Four Hour Working Time
• Plane to Approximate Round
• Rig a Powered Mast Turning System
• Sand Mast to Smooth Round
• Fiberglass the Mast
Bird’s Mouth Boom
Ten Staves with Two Wider Staves to Form an Oval

Calculator 1: Given N, calculate the two angles used for the V-notch on the staves.

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Calculator 4: Given N, O.D. and H, calculate L, I.D. and K

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Bird’s Mouth Spar
Weight Saving - at Same Strength

Weight Saving - at Same Strength (%)

- 6 sides
- 8 sides
- 9 sides
- 10 sides
- 12 sides
- Size Increase

Ratio A (I.D. / O.D.)
Building a Stitch and Glue Boat (Nelson)