Marine Composites

Webb Institute
Senior Elective

Design of Structural Details

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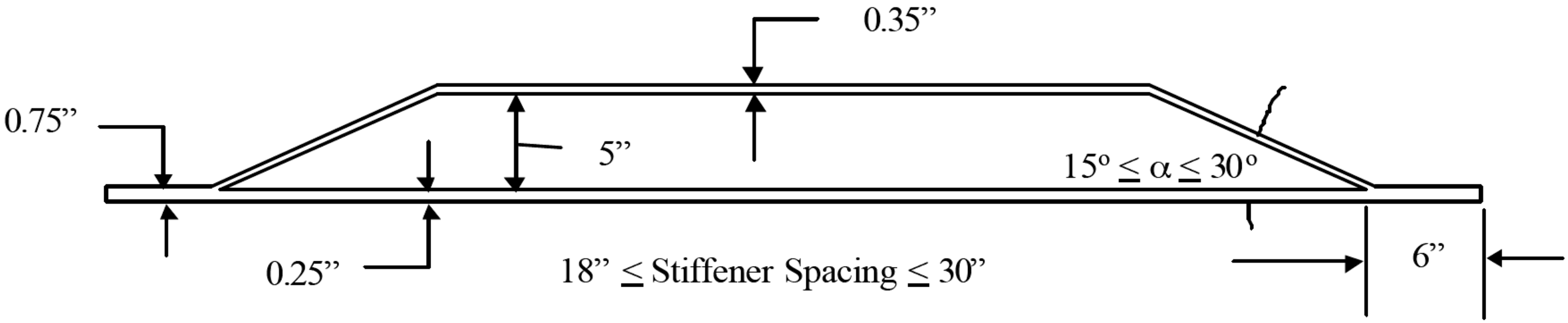
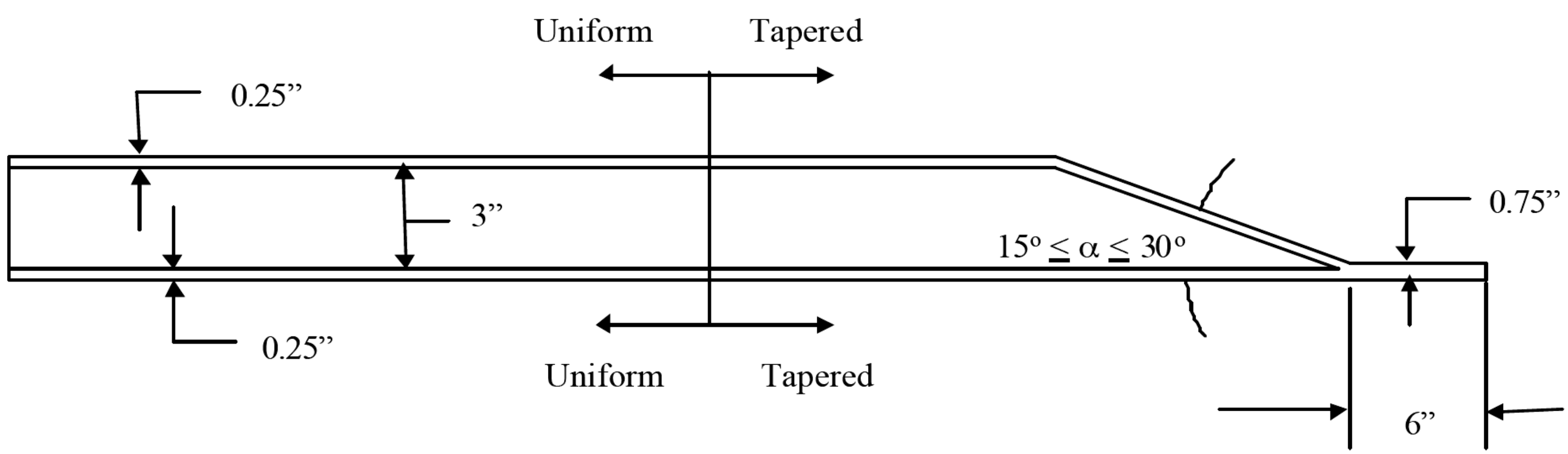
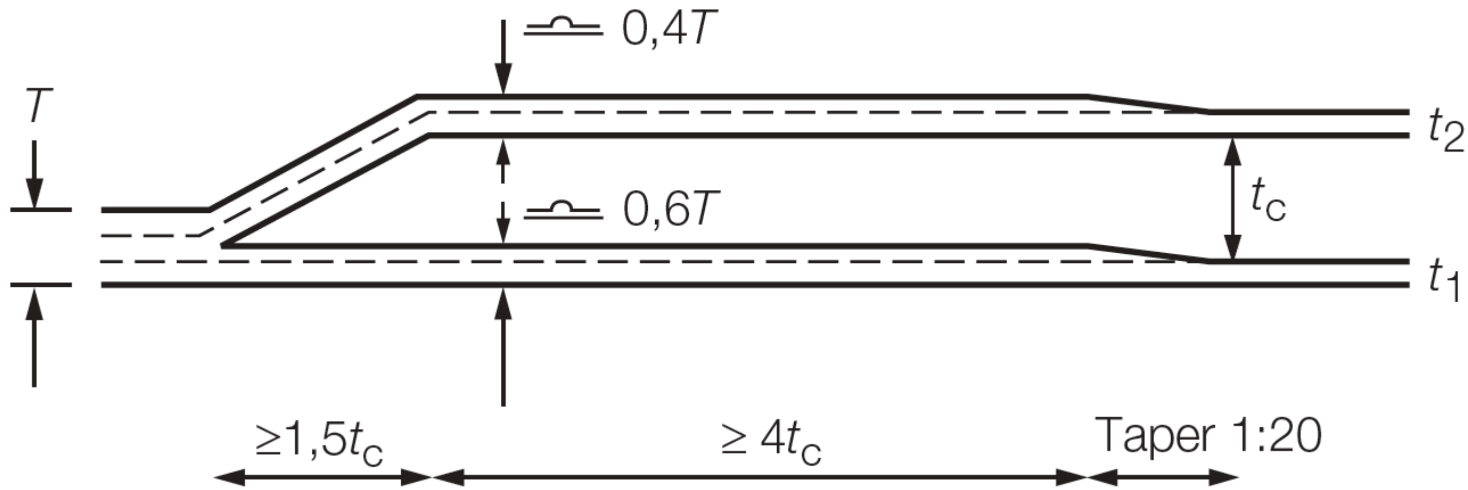
Typical Parameters for Sandwich Panels

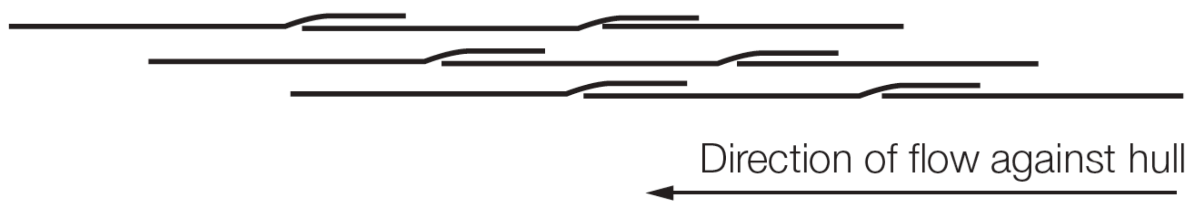




Single Skin/Sandwich Skin Intersection Detail

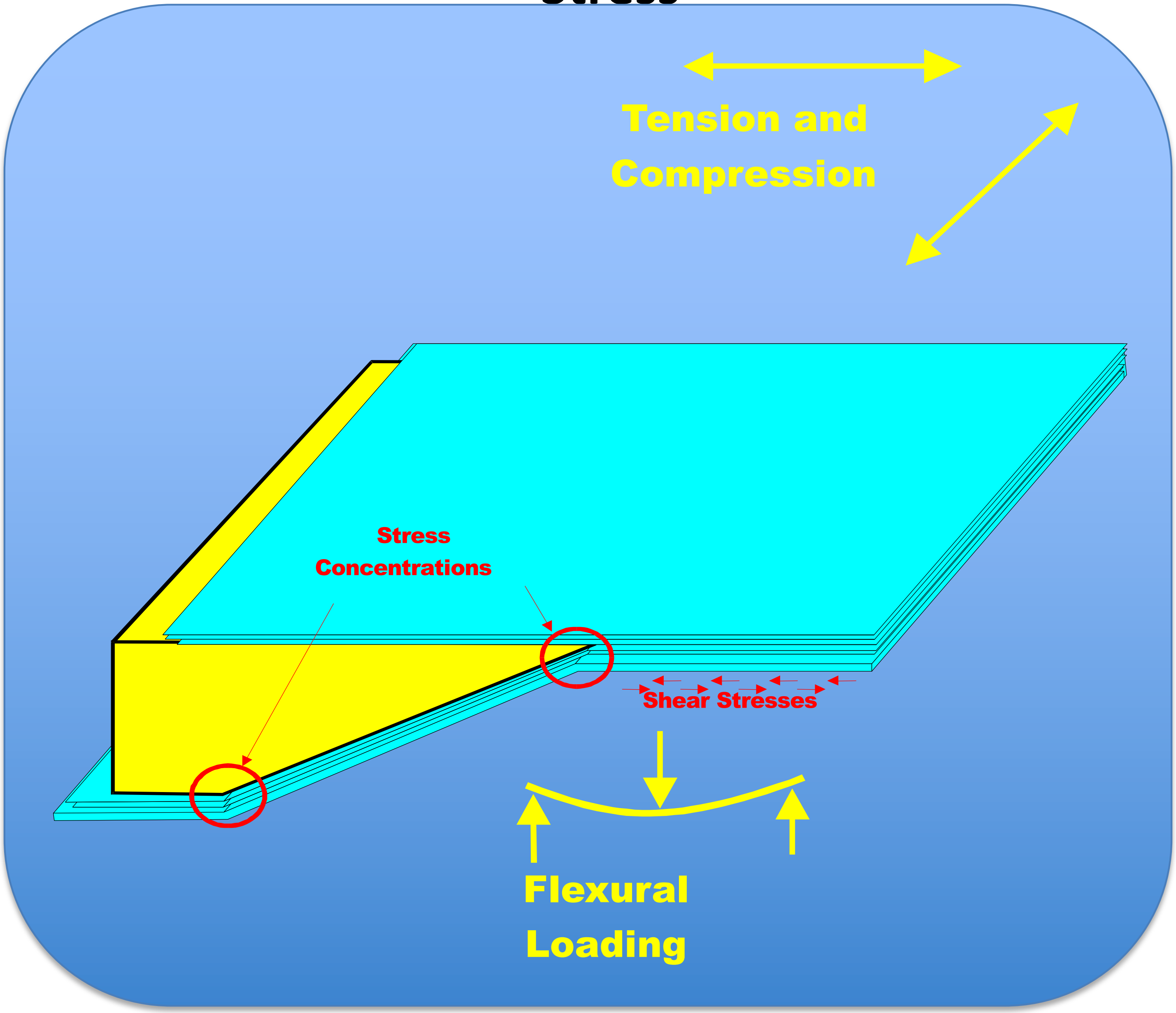


Arrangement of hull reinforcement

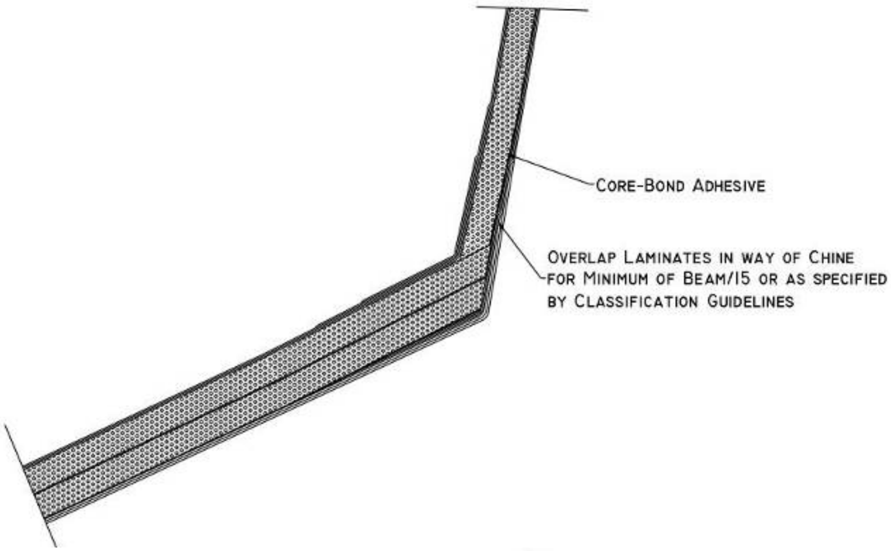


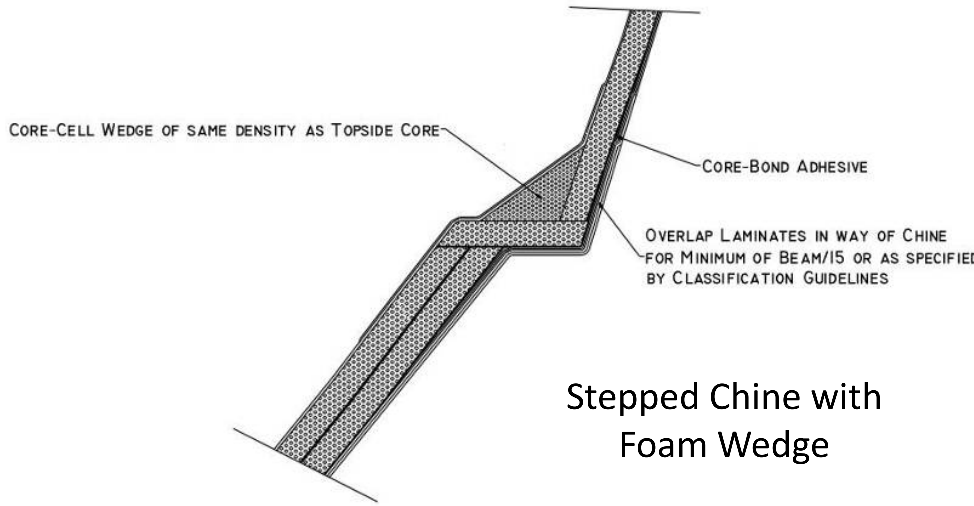
LLOYD'S REGISTER *RULES AND REGULATIONS FOR THE CLASSIFICATION OF SPECIAL SERVICE CRAFT*, July 2010
Scantling Determination for Mono-Hull Craft

Sandwich-to-Solid Transition Stress

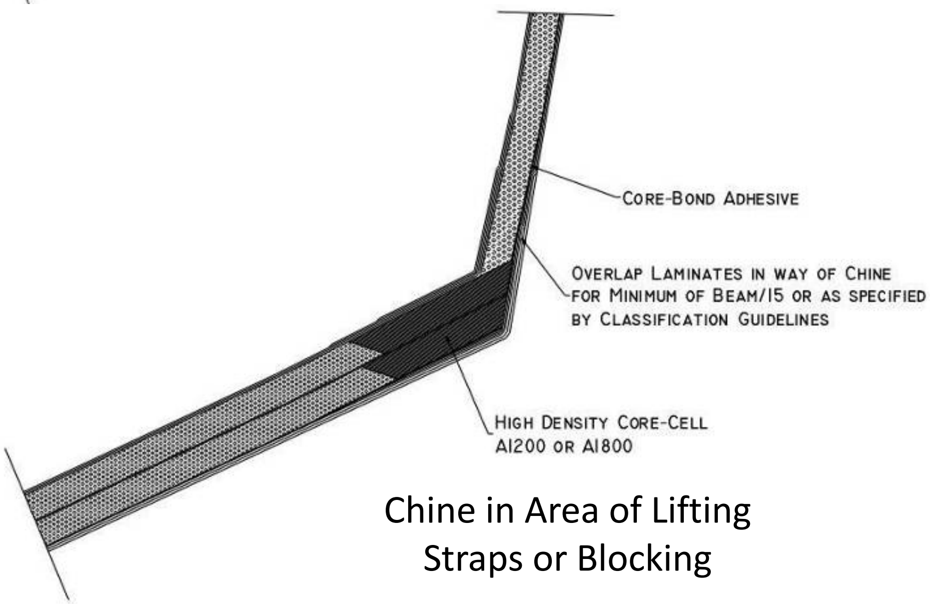


Chine Details

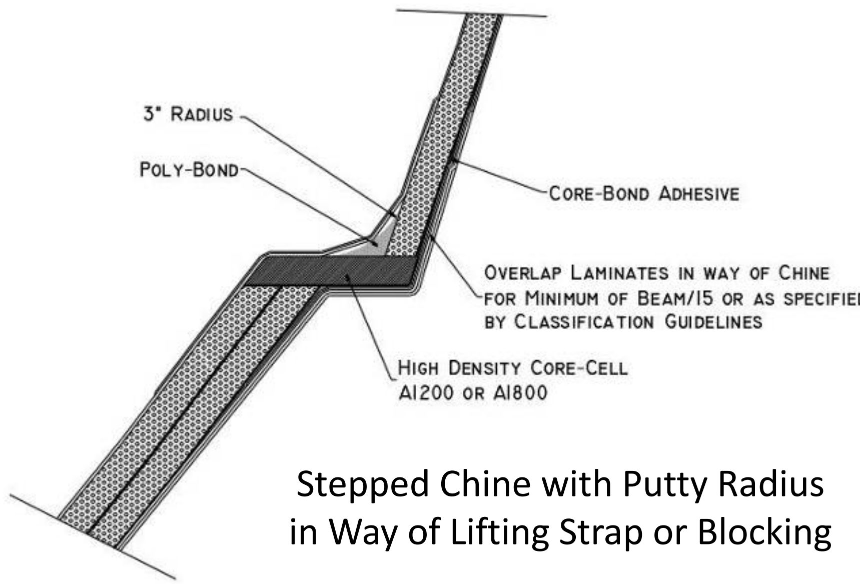




Stepped Chine with Foam Wedge



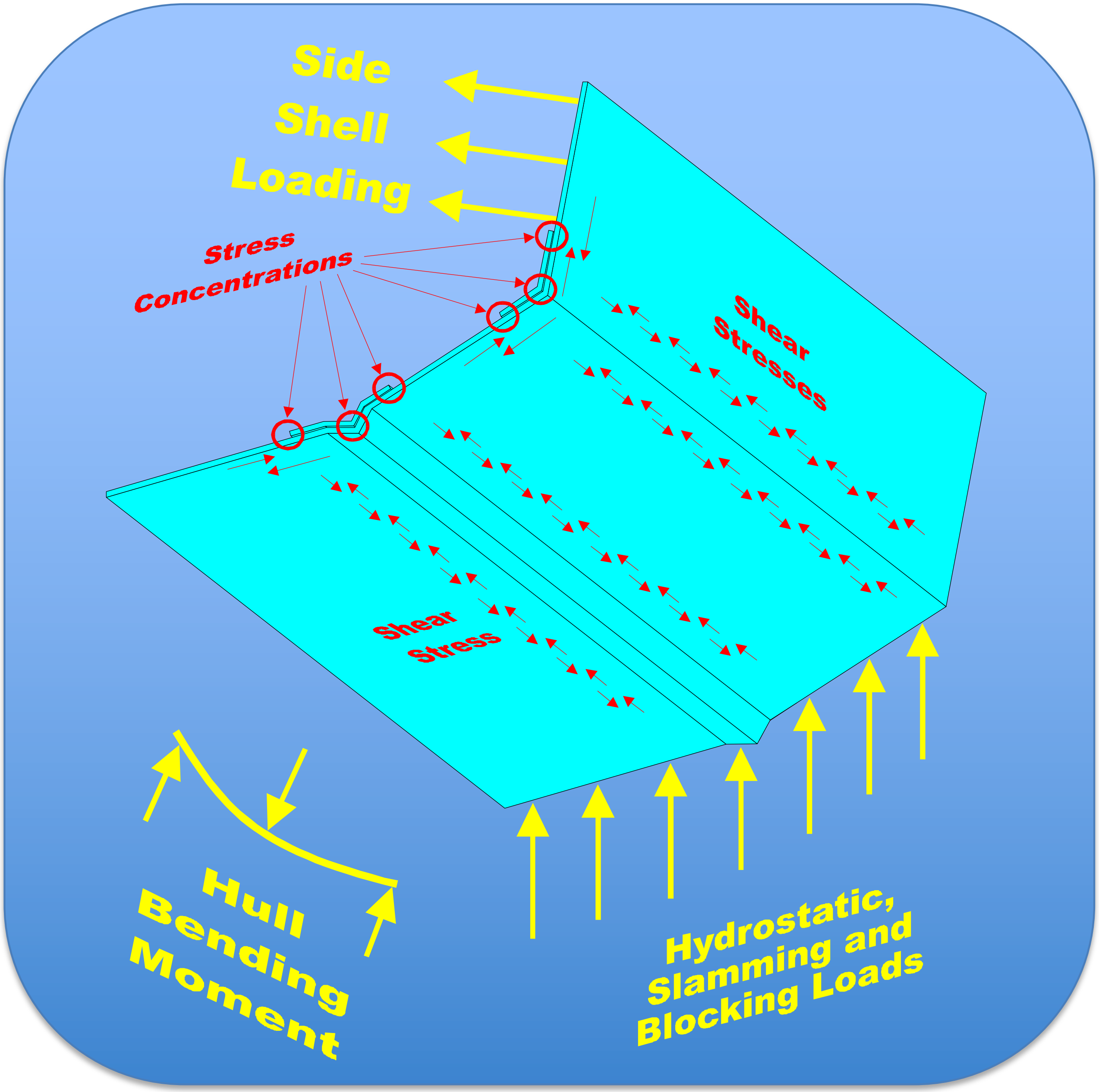
Chine in Area of Lifting Straps or Blocking



Stepped Chine with Putty Radius in Way of Lifting Strap or Blocking

Illustrations courtesy of ATC Chemical Corporation (now Gurit). Drawing is for guidance only – actual laminates should be engineered to specific requirements in accordance with classification society rules.

Chine & Spray Strake Stress

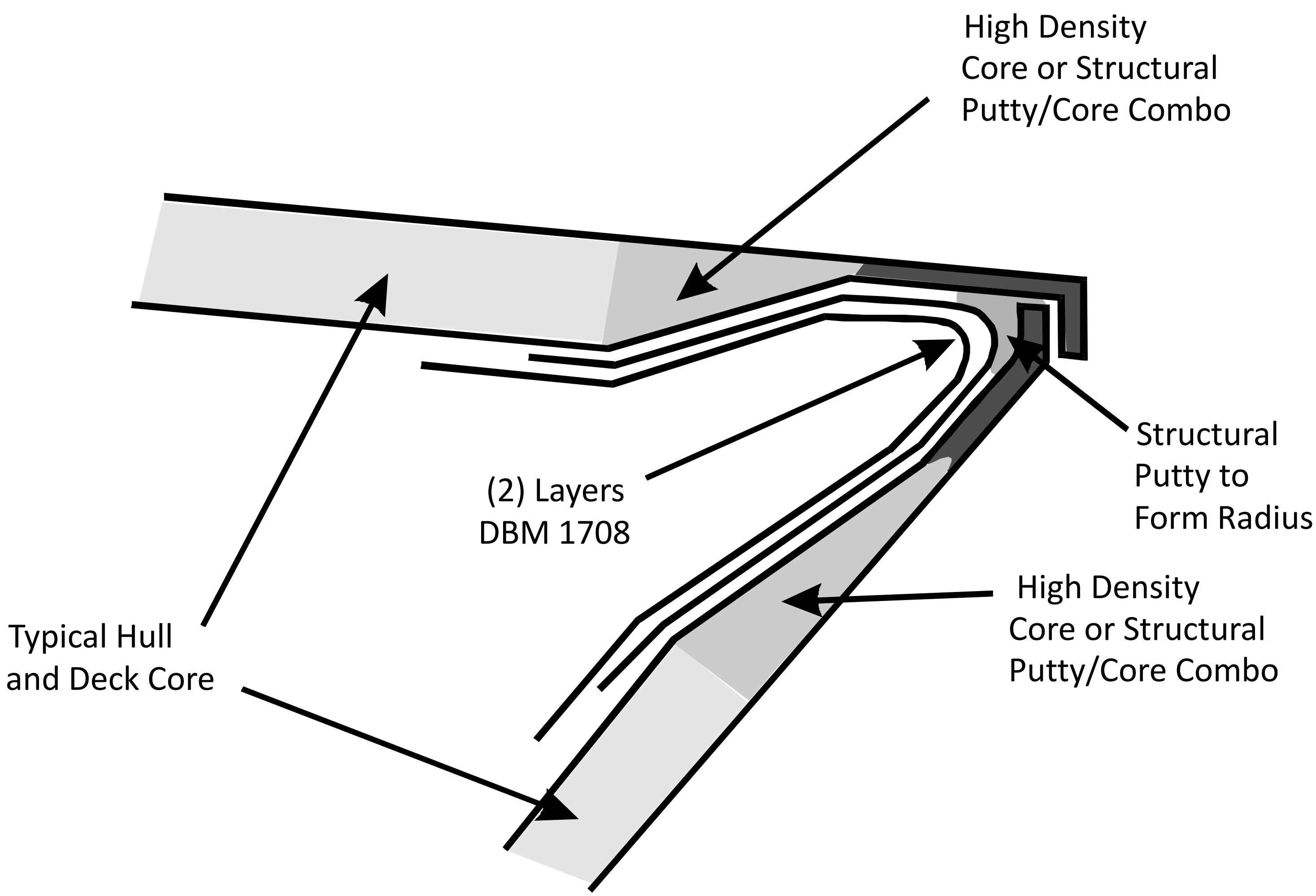


Hull-to-Deck Joints

There are about as many specific ways to create an effective hull-to-deck joint as there are builders. Whether adhesive or fiberglass is used to create the watertight joint, some basic principles should be kept in mind:

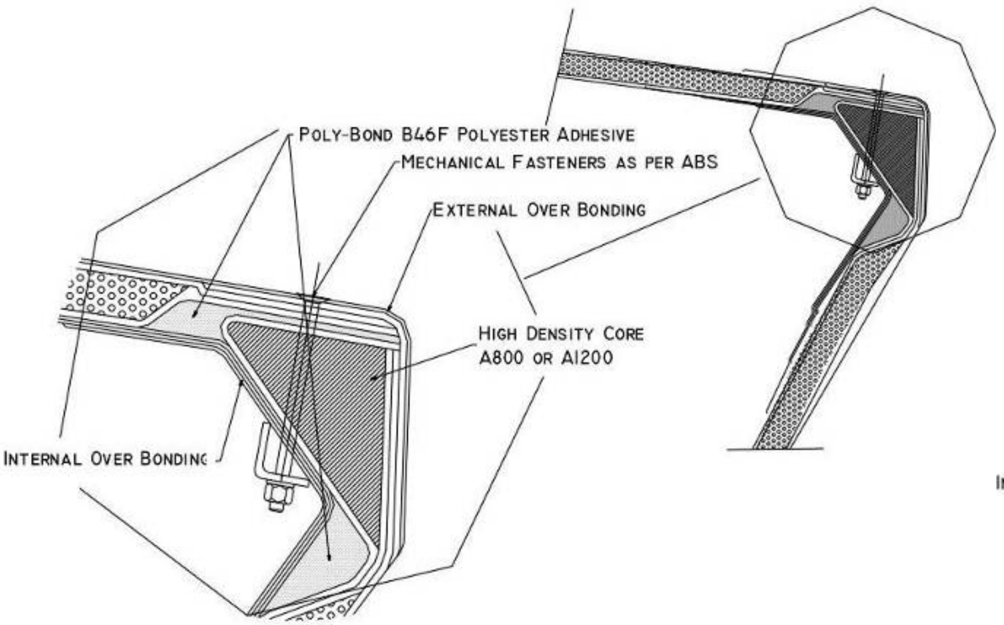
- The effectiveness of the joint will be proportional to the width of the mating surface area so care should be exercised when trimming hull and deck flanges
- Adhere to prescribed flange and tabbing laminate schedule
- Building good joints in tight corners is difficult - use structural putties
- Flat mating surfaces will create a consistent bondline
- Some adhesives do not require sanding of mating surfaces. However, mating surface should always be clean regardless of bonding method

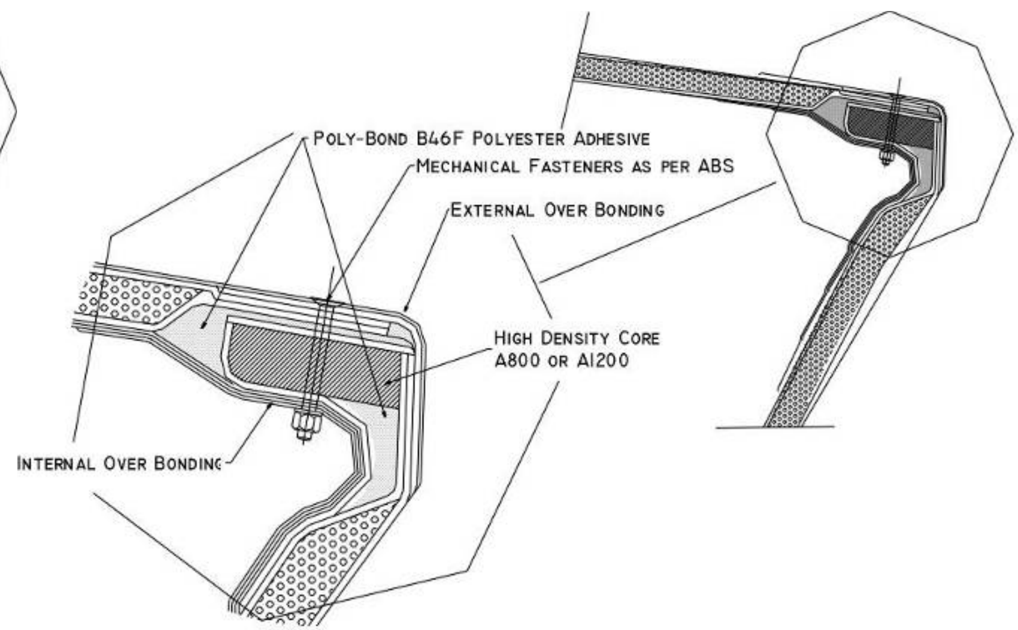
Typical Hull-to-Deck Joint Construction



Typical Hull-to-Deck Joint Showing Structural Putty used to Reduce Stress Concentrations. Tight Corner for Laminating is One Reason Many Builders Now Use Adhesives to Obtain More Consistent Results

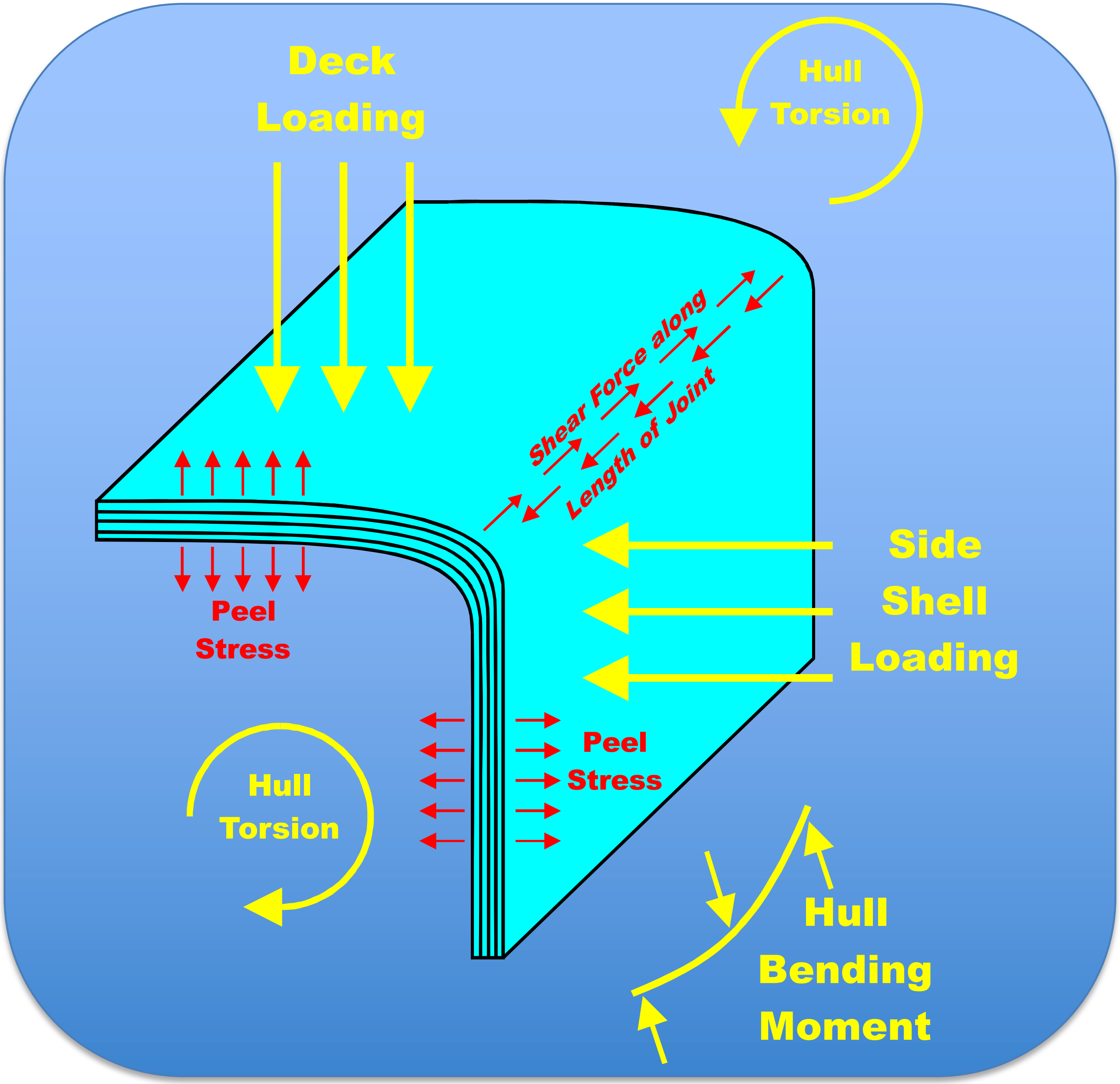
Sandwich Hull-to-Deck Joint Detail



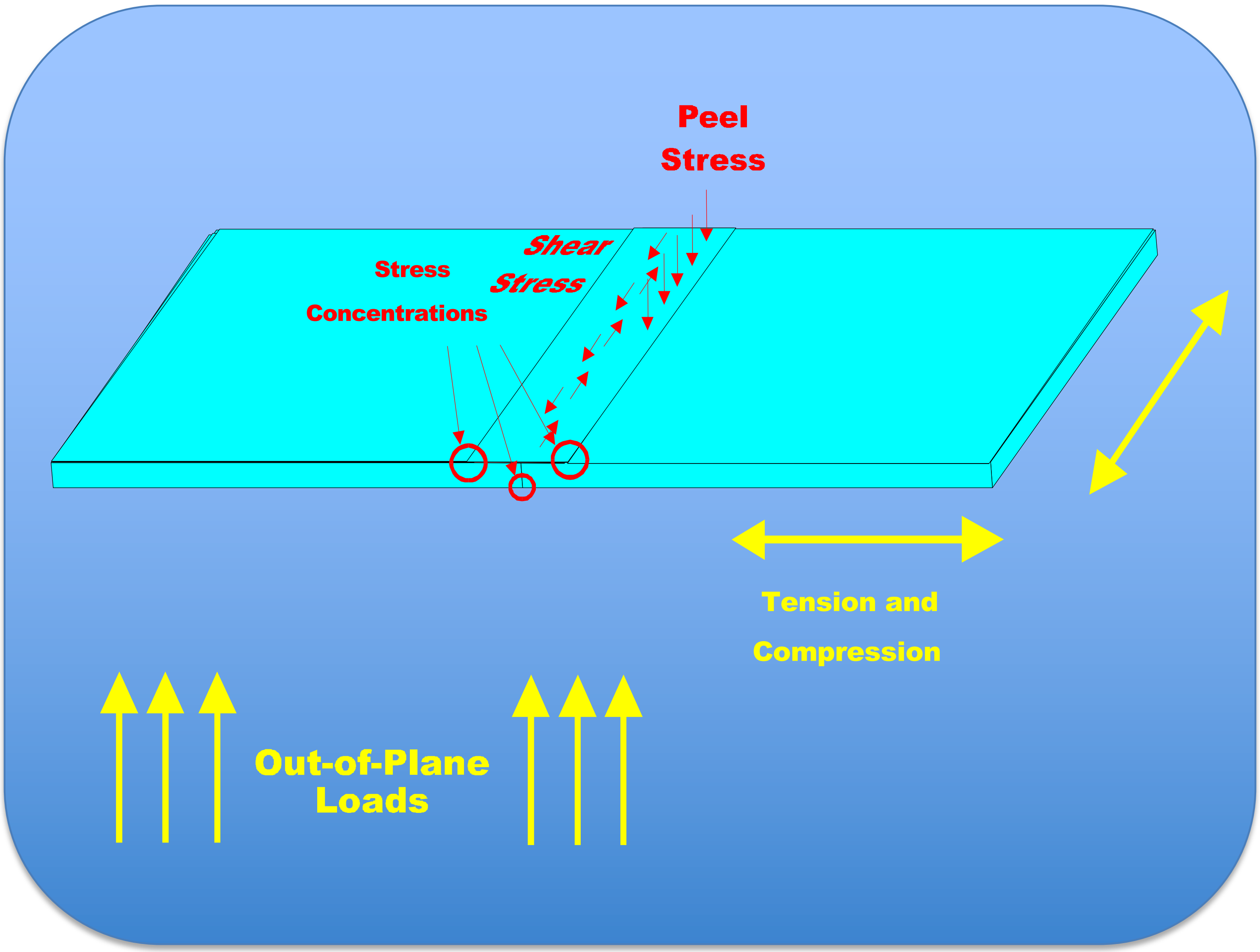


Illustrations courtesy of ATC Chemical Corporation (now Gurit). Drawing is for guidance only – actual laminates should be engineered to specific requirements in accordance with classification society rules.

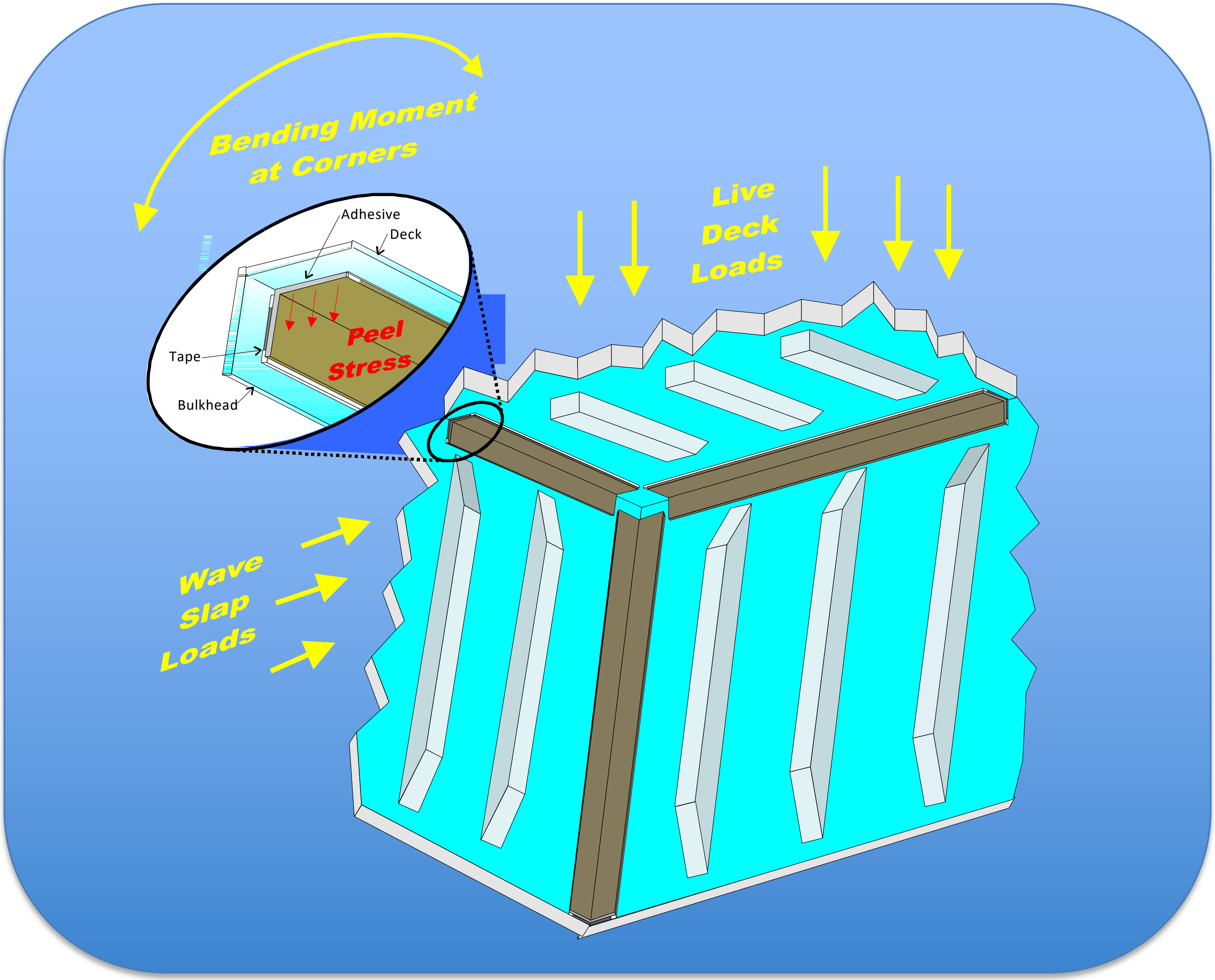
Hull-to-Deck Joint Stresses



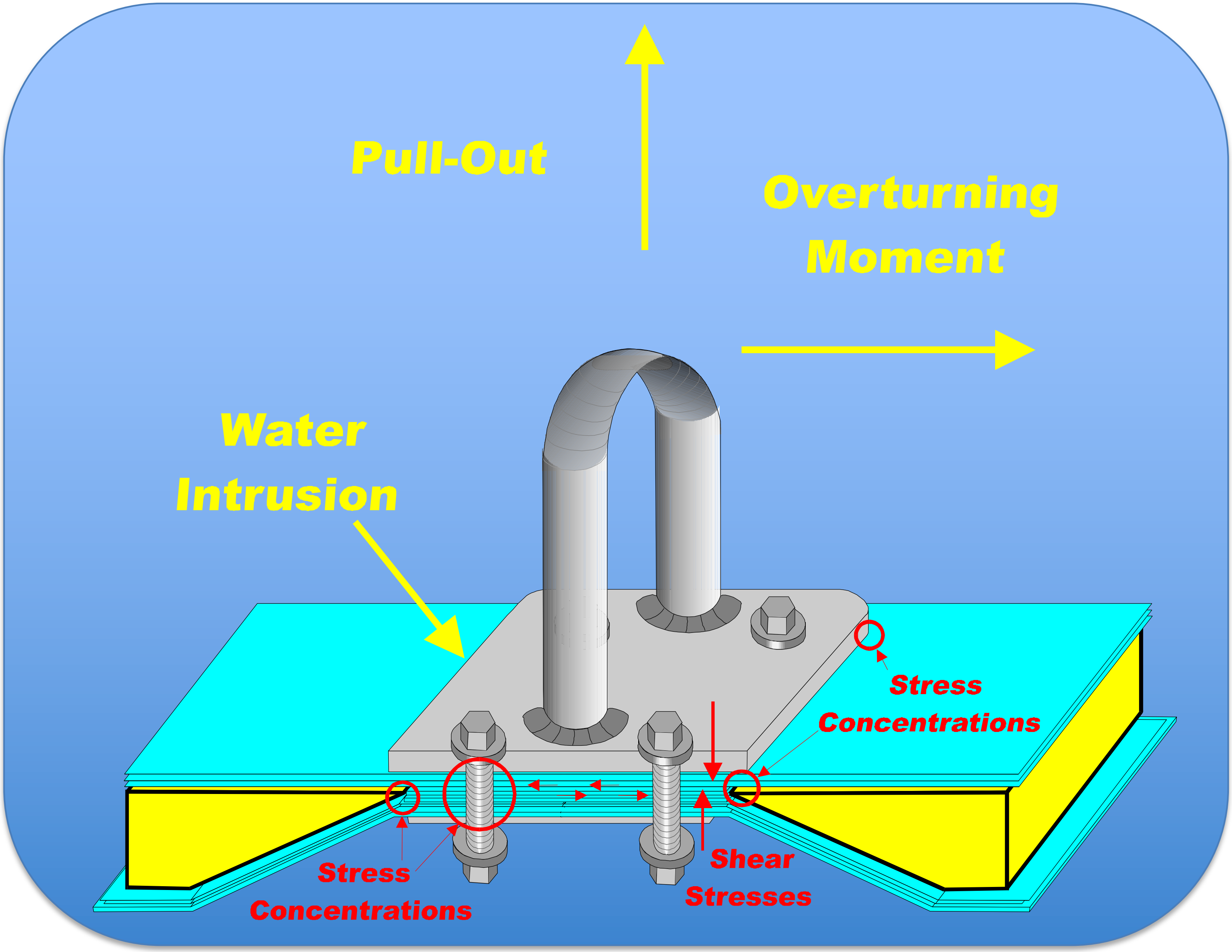
Secondary Bonded Joint Stress



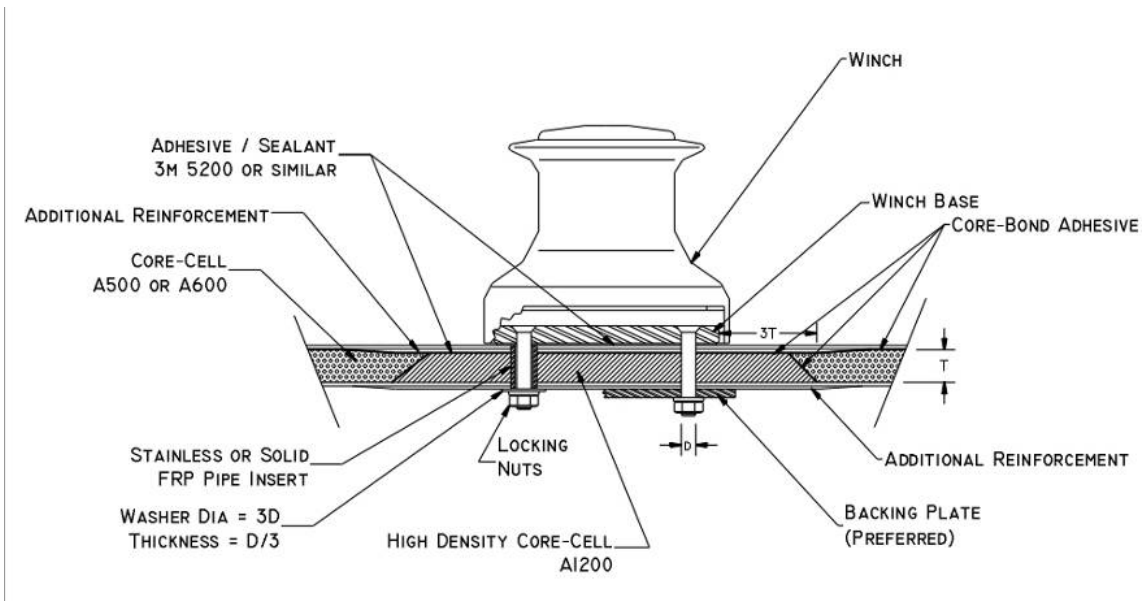
Adhesively Bonded Joint Stress

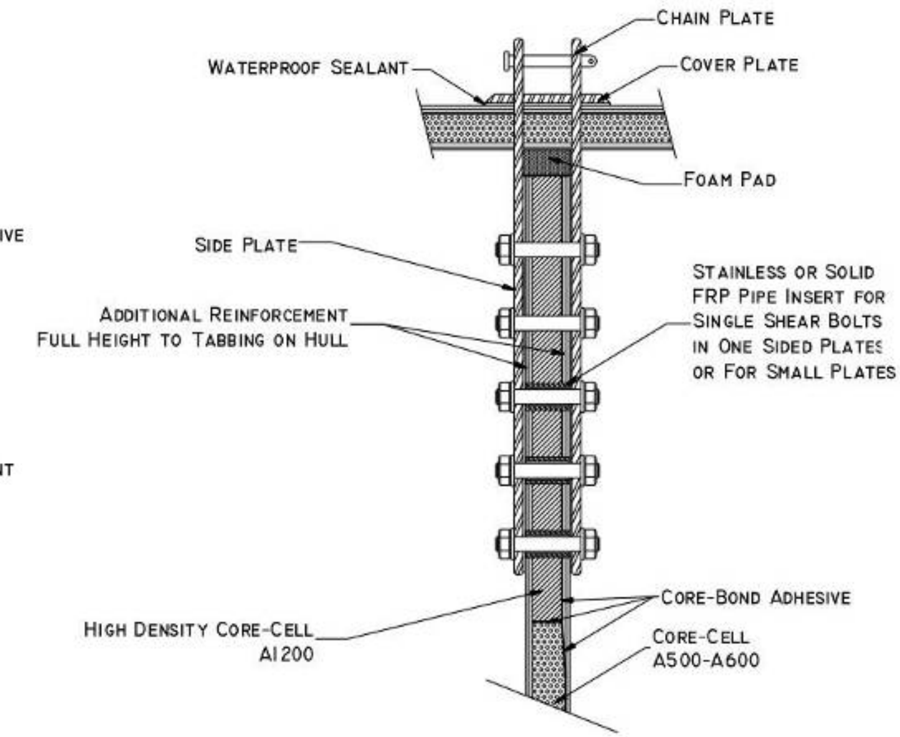


Deck Hardware Stresses



Sailboat Hardware





Illustrations courtesy of ATC Chemical Corporation (now Gurit). Drawing is for guidance only – actual laminates should be engineered to specific requirements in accordance with classification society rules.

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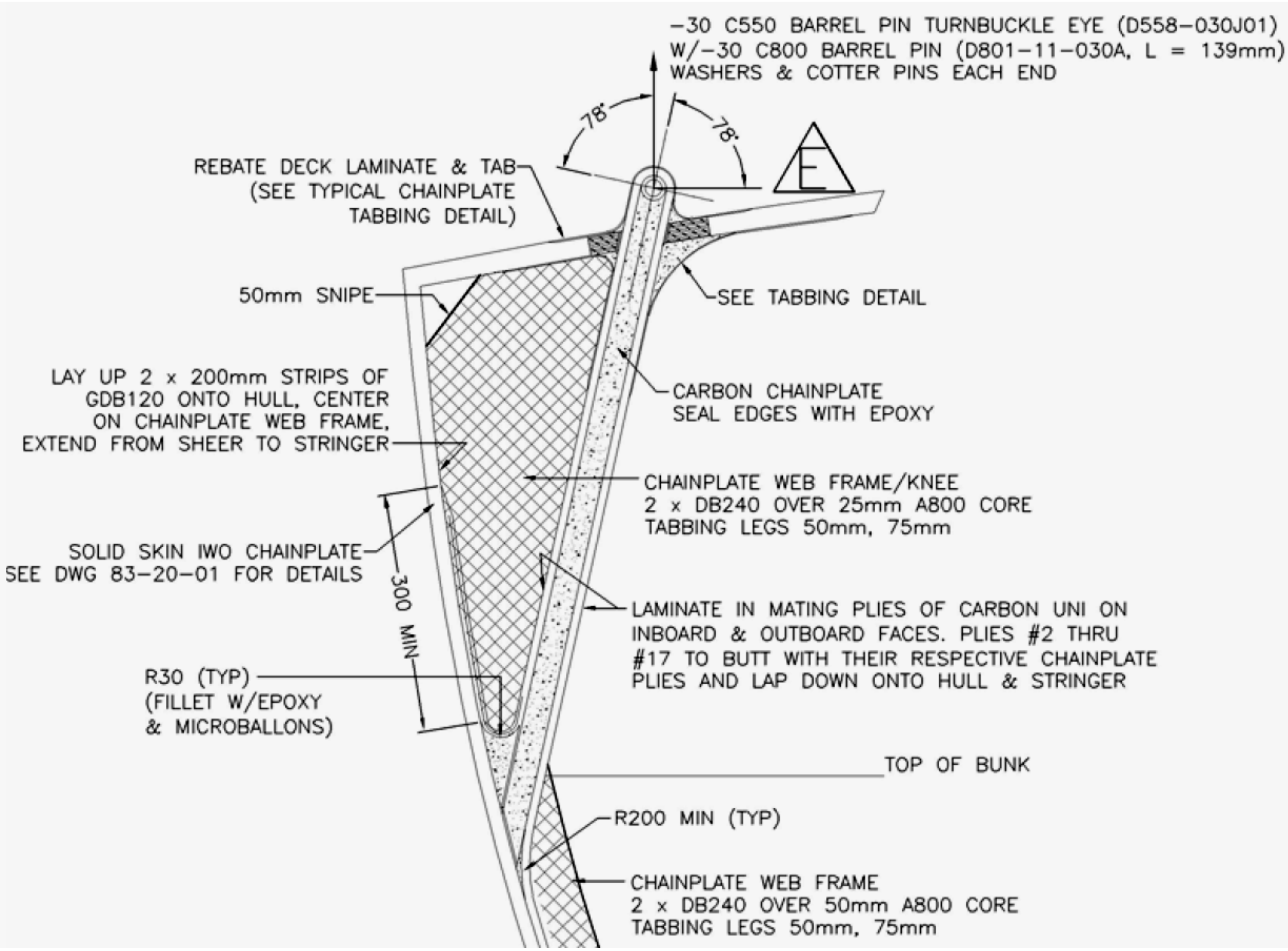
Carbon Fiber Chainplates



David Pedrick & Gram Schweikert, “Design of the Navy 44 STC MKII,” Annapolis, MD, April, 2005

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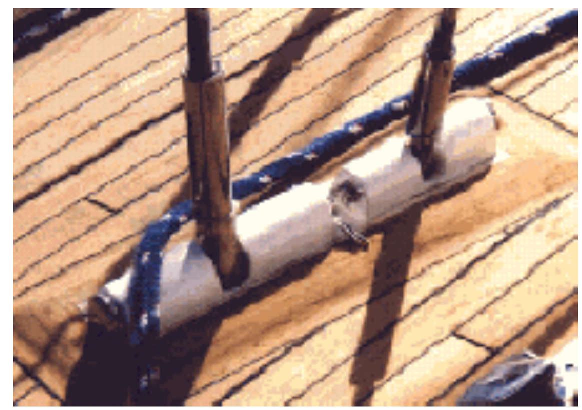
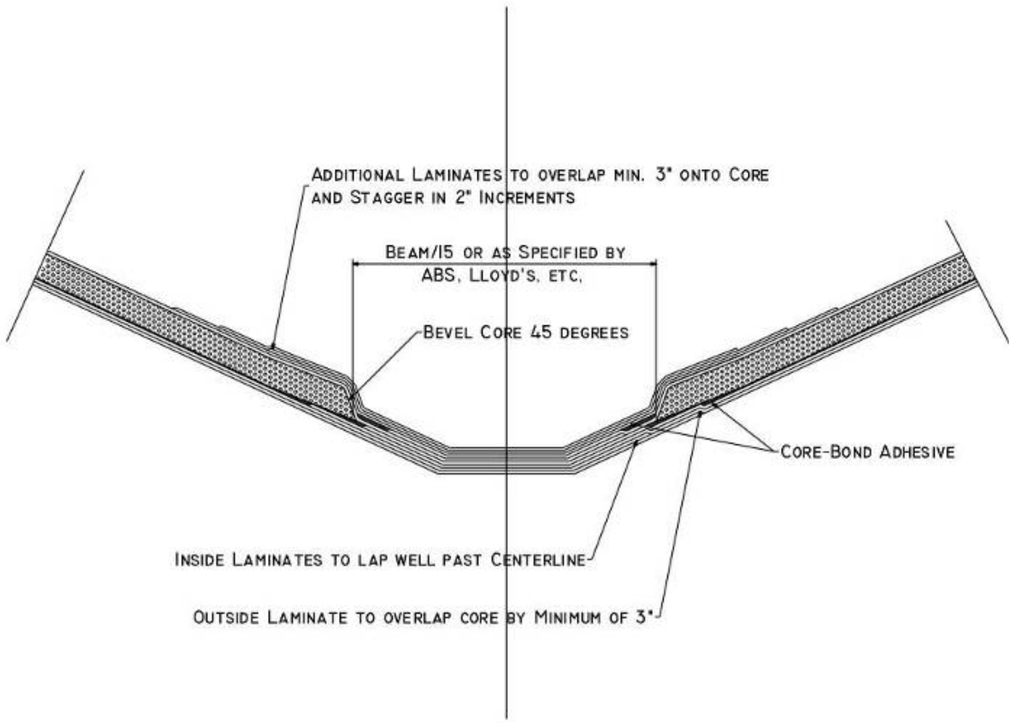
Examples of Composite Chainplates

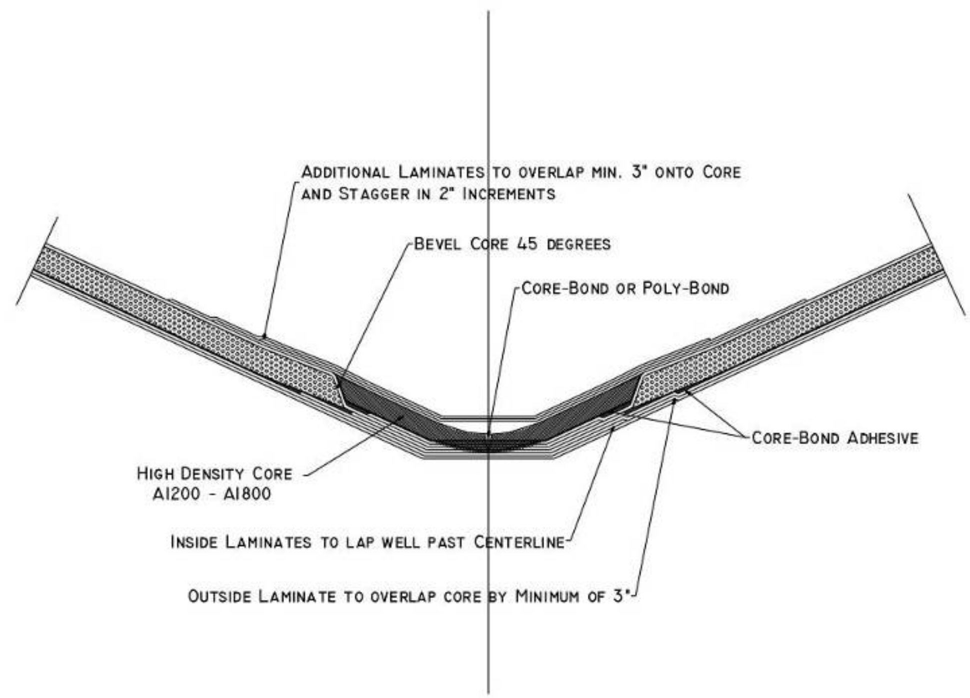
Composite chainplates featured on 15 meter IMS racer built by New England Boatworks

Composite chainplates developed by Van Gorkom Yacht Design



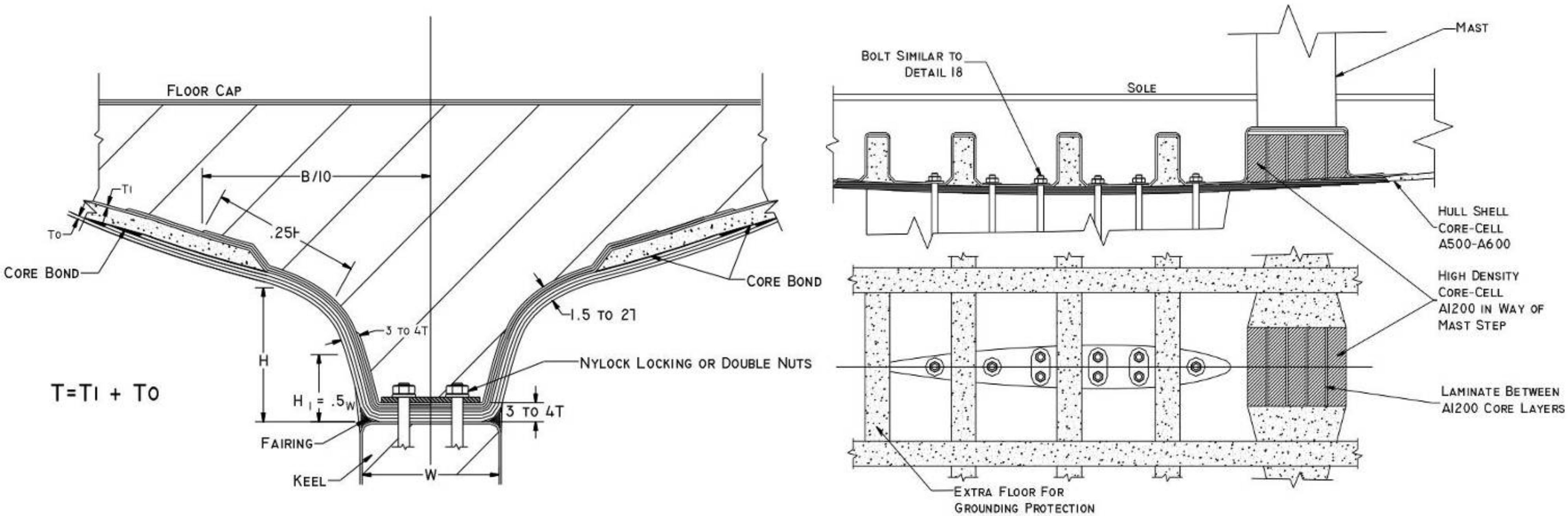
Solid Centerline Detail





Illustrations courtesy of ATC Chemical Corporation (now Gurit). Drawing is for guidance only – actual laminates should be engineered to specific requirements in accordance with classification society rules.

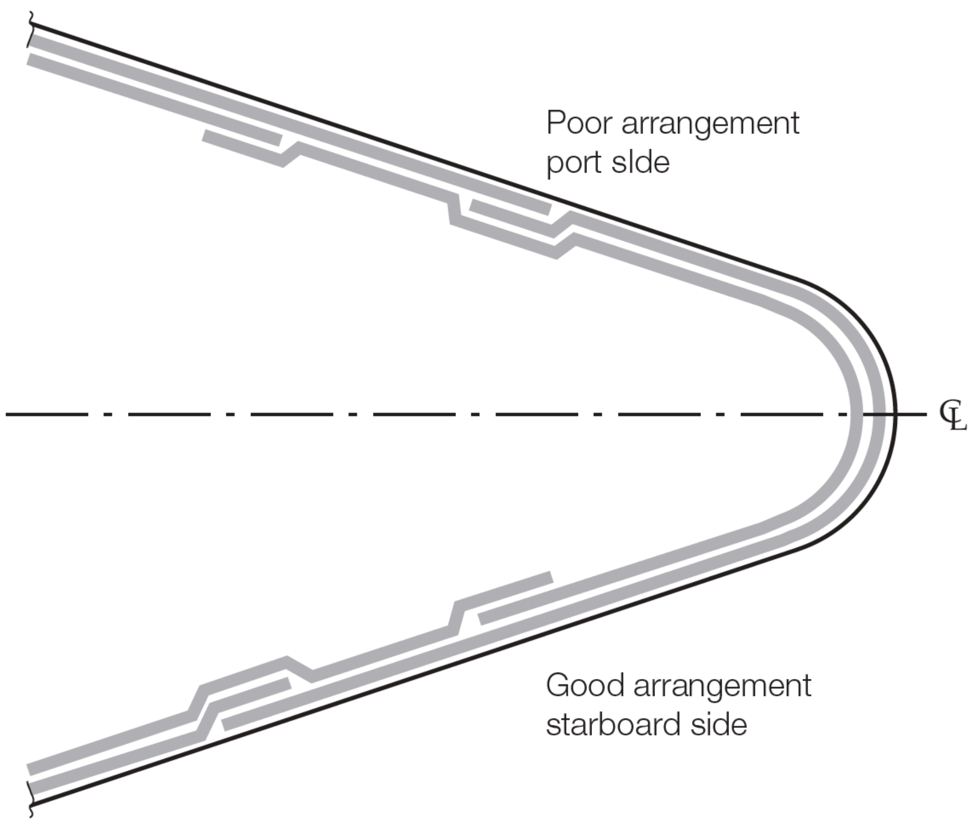
Keel Attachment Detail



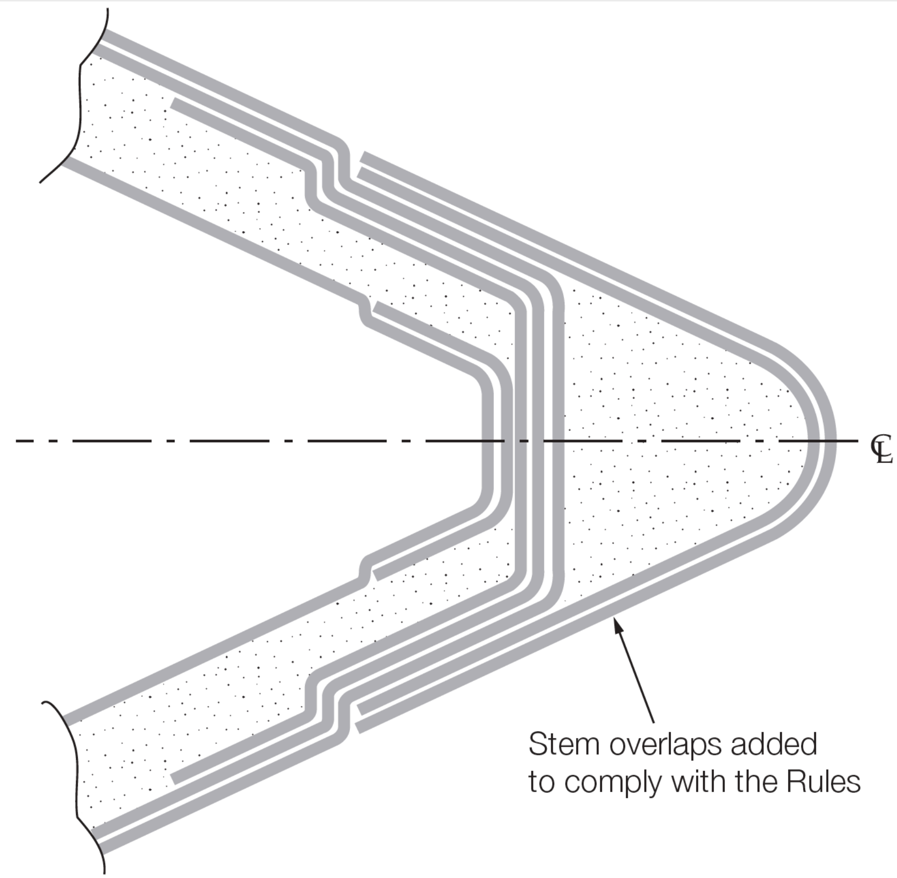
Illustrations courtesy of ATC Chemical Corporation (now Gurit). Drawing is for guidance only – actual laminates should be engineered to specific requirements in accordance with classification society rules.

Bow Laminate Details

Arrangement of laminate in way of forefoot and stem

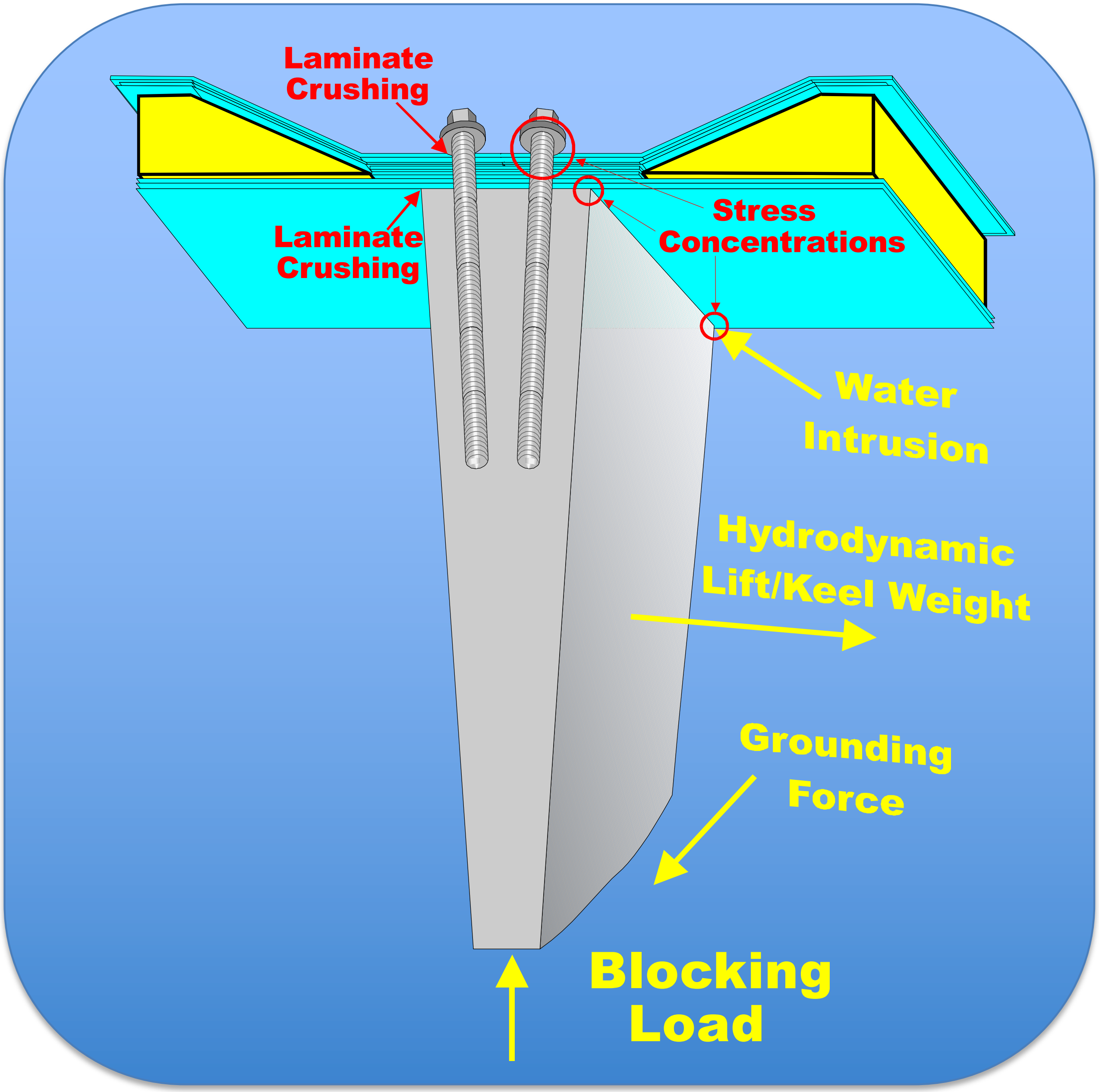


'Sacrificial nose'

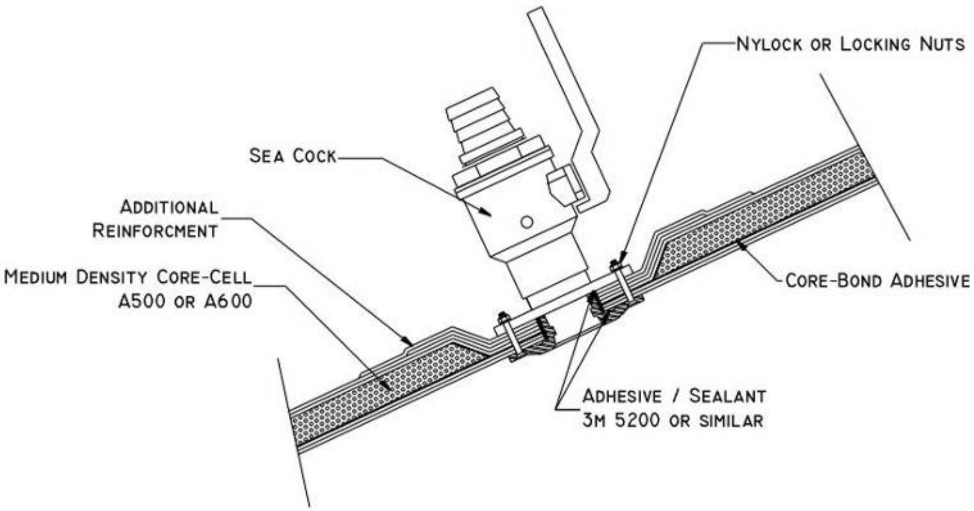


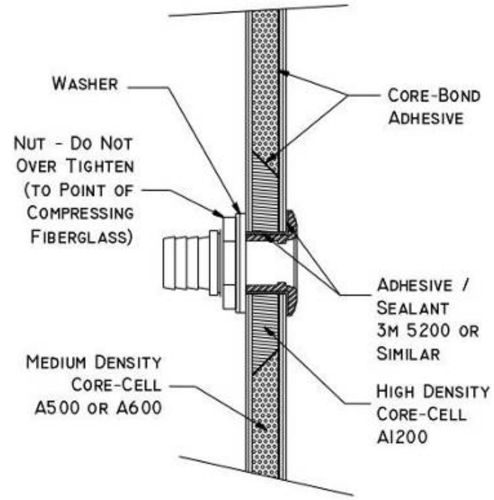
LLOYD'S REGISTER *RULES AND REGULATIONS FOR THE CLASSIFICATION OF SPECIAL SERVICE CRAFT*, July 2010
Scantling Determination for Mono-Hull Craft

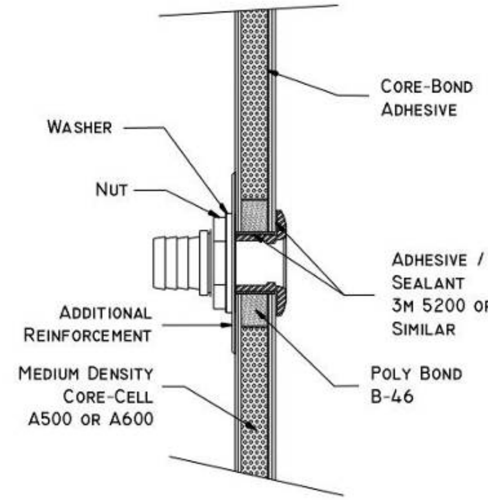
Sailboat Keel Loads



Through-Hull Fitting Details



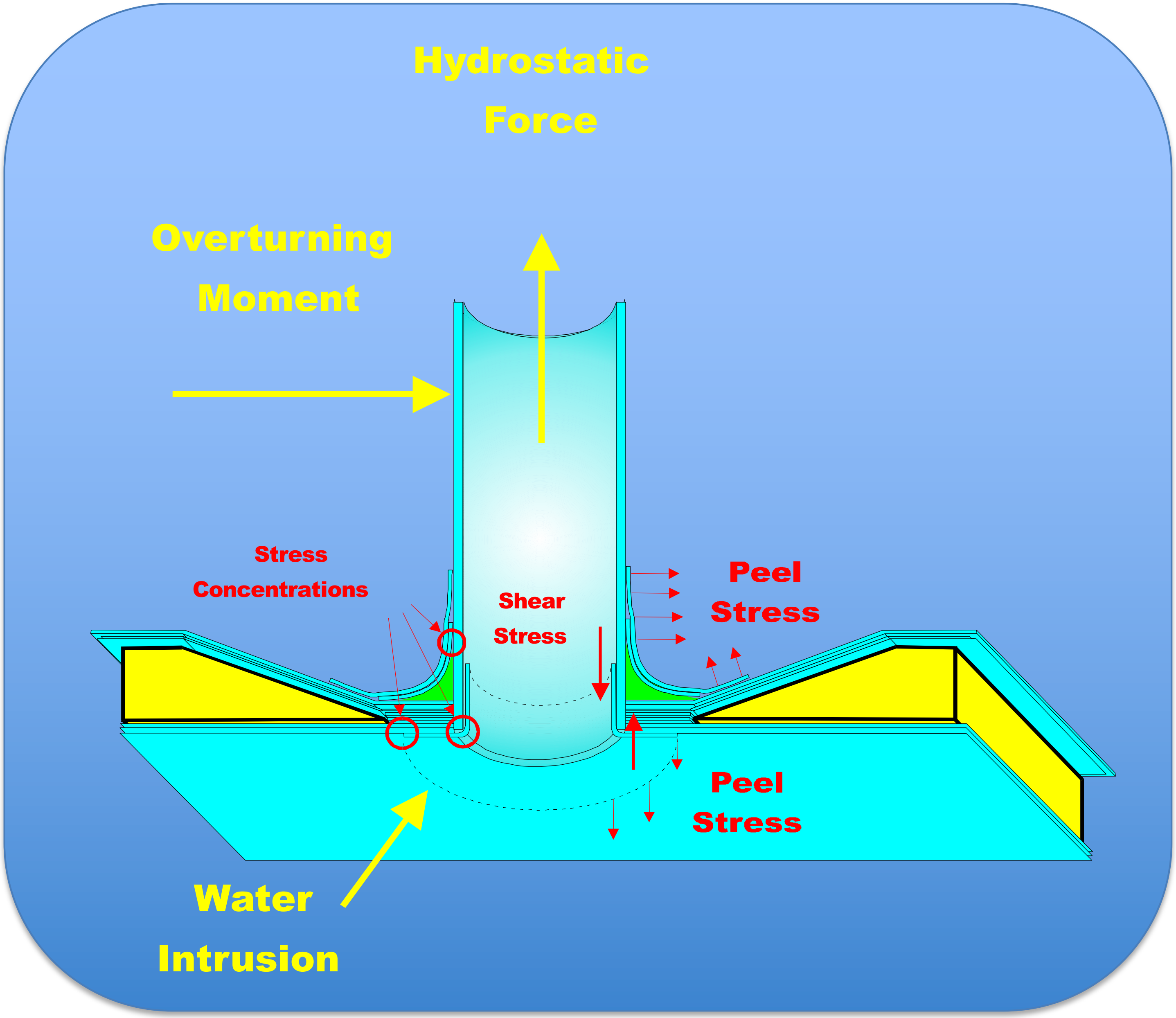




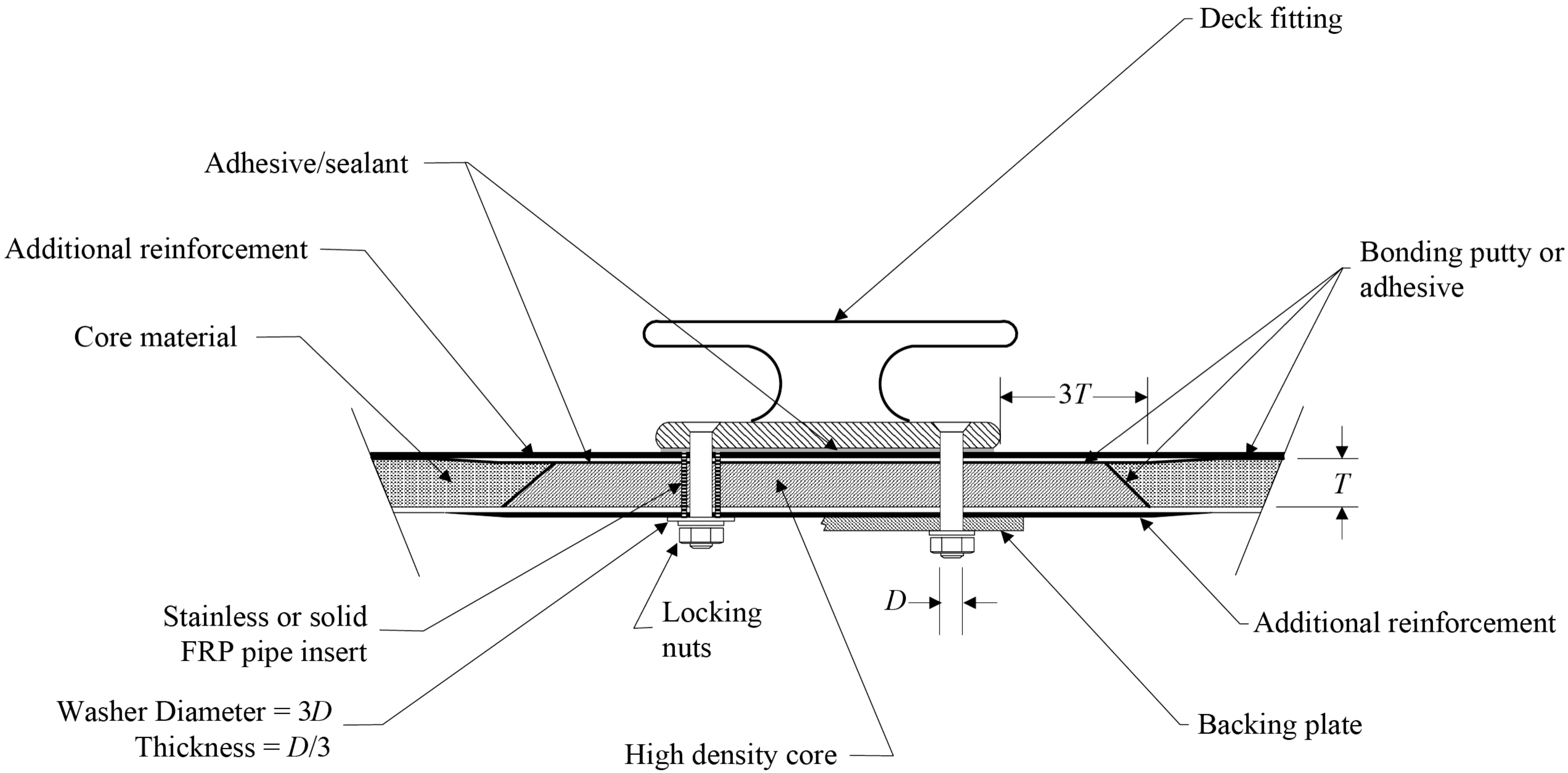
Illustrations courtesy of ATC Chemical Corporation (now Gurit). Drawing is for guidance only – actual laminates should be engineered to specific requirements in accordance with classification society rules.

Example of through-hull close-out showing putty used to create fillet

Through-Hull Penetration Stress

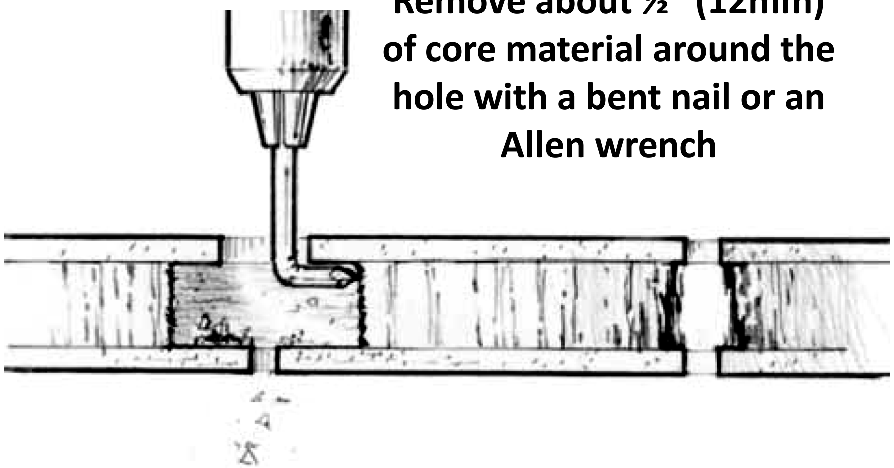


Deck Fittings

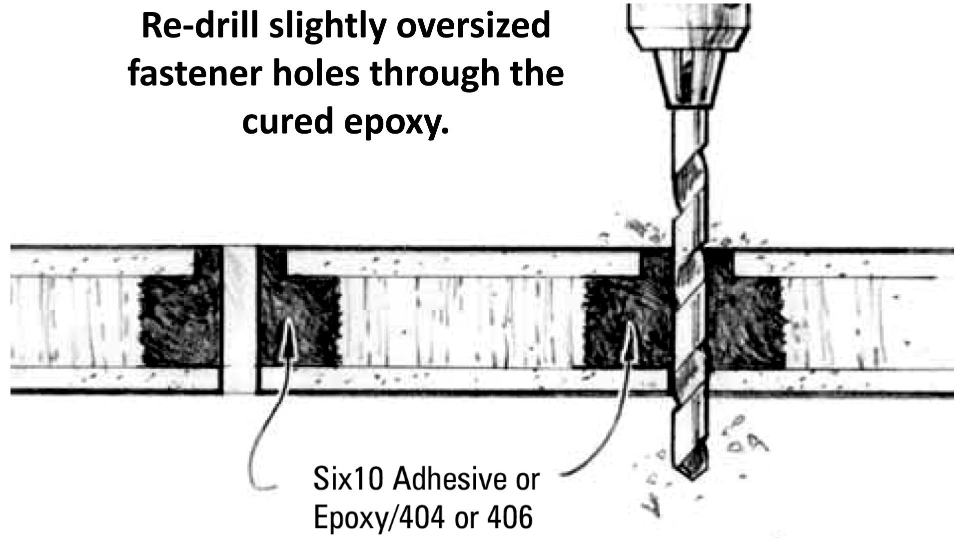


Fasteners with Sandwich Laminates

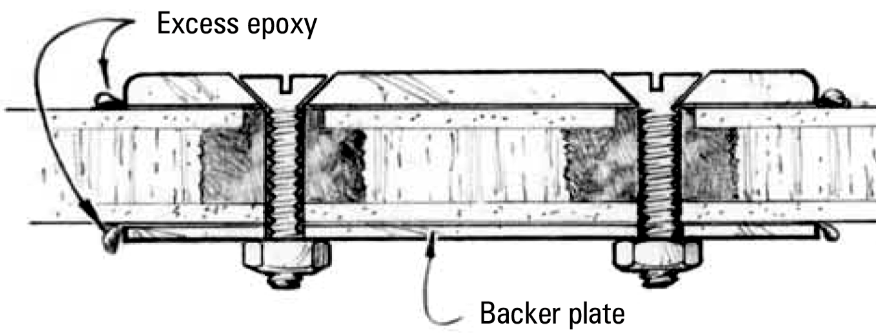
Remove about ½" (12mm) of core material around the hole with a bent nail or an Allen wrench



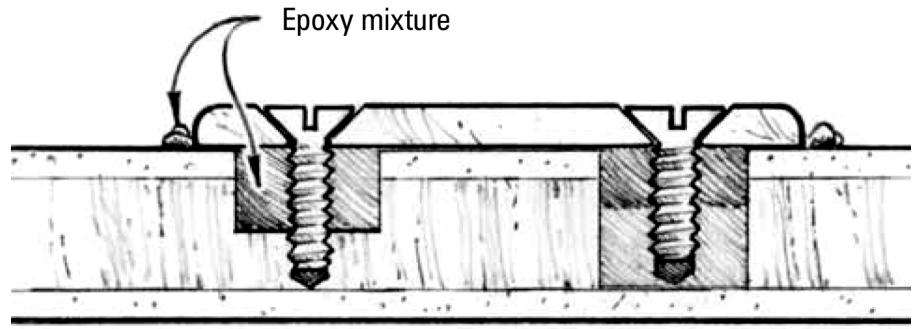
Re-drill slightly oversized fastener holes through the cured epoxy.



Tighten the nuts until epoxy begins to squeeze from the sides of hardware item and backing plate.



Partially fill with epoxy if core is too damaged to hold fastener.



Gougeon Brothers Inc., “WEST System Fiberglass Boat Repair & Maintenance,” 15th Edition, April 2011

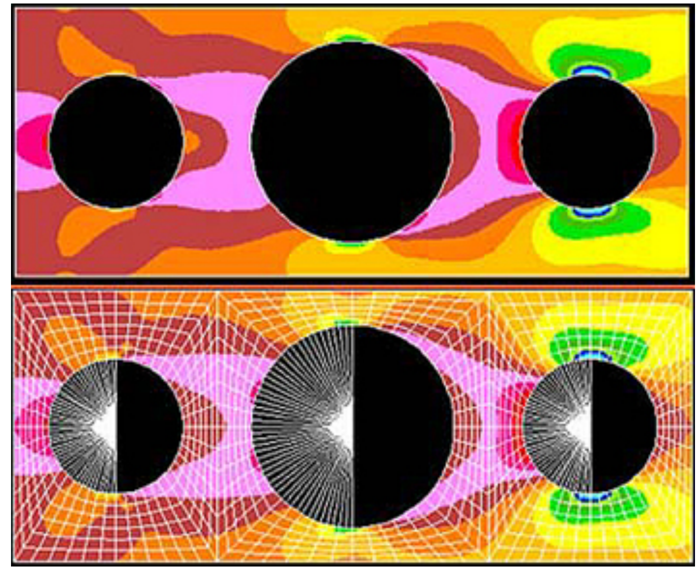
Fastener Holding Power

Holding forces in mat/polyester laminates

Thread Size	Axial Holding Force				Lateral Holding Force			
	Minimum		Maximum		Minimum		Maximum	
	Depth (ins)	Force (lbs)	Depth (ins)	Force (lbs)	Depth (ins)	Force (lbs)	Depth (ins)	Force (lbs)
Machine Screws								
4 - 40	.1250	40	.3125	450	.0625	150	.1250	290
6 - 32	.1250	60	.3750	600	.0625	180	.1250	380
8 - 32	.1250	100	.4375	1150	.0625	220	.1875	750
10 - 32	.1250	150	.5000	1500	.1250	560	.2500	1350
1/4 - 20	.1875	300	.6250	2300	.1875	1300	.3125	1900
5/16 - 18	.1875	400	.7500	3600	.1875	1600	.4375	2900
3/8 - 16	.2500	530	.8750	5000	.2500	2600	.6250	4000
7/16 - 14	.2500	580	1.0000	6500	.3125	3800	.7500	5000
1/2 - 13	.2500	620	1.1250	8300	.3750	5500	.8750	6000
9/16 - 12	.2500	650	1.2500	10000	.4375	6500	.9375	8000
5/8 - 11	.2500	680	1.3750	12000	.4375	6800	1.0000	11000
3/4 - 10	.2500	700	1.5000	13500	.4375	7000	1.0625	17000
Self-Tapping Thread Cutting Screws								
4 - 40	.1250	80	.4375	900	.1250	250	.1875	410
6 - 32	.1250	100	.4375	1100	.1250	300	.2500	700
8 - 32	.2500	350	.7500	2300	.1875	580	.3750	1300
10 - 32	.2500	400	.7500	2500	.1875	720	.4375	1750
1/4 - 20	.3750	600	1.0625	4100	.2500	1600	.6250	3200
Self-Tapping Thread Forming Screws								
4 - 24	.1250	50	.3750	500	.1250	220	.1875	500
6 - 20	.1875	110	.6250	850	.1250	250	.2500	600
8 - 18	.2500	180	.8125	1200	.1875	380	.3125	850
10 - 16	.2500	220	.9375	2100	.2500	600	.5000	1500
14 - 14	.3125	360	1.0625	3200	.2500	900	.6875	2800
5/16 - 18	.3750	570	1.1250	4500	.3125	1800	.8125	4400
3/8 - 12	.3750	700	1.1250	5500	.3750	3600	1.0000	6800

Gibbs and Cox, Marine Design Guide for FRP, 1960

Typical bolted joint stress field

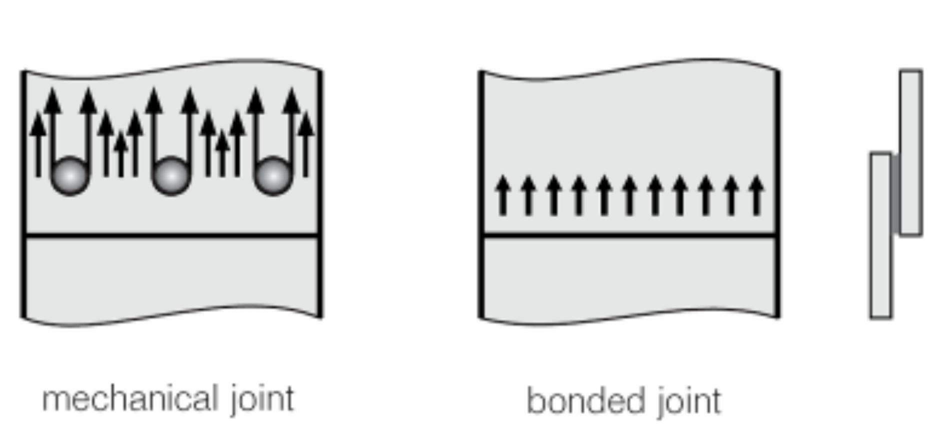


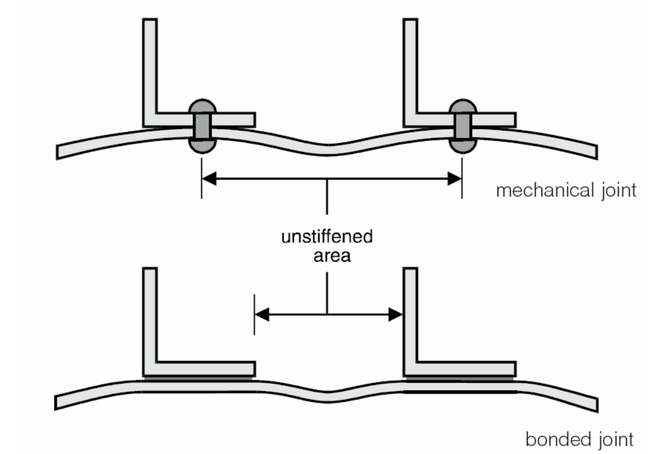
DDG 100 deckhouse joint

Northrop Grumman Shipbuilding

eric greene associates

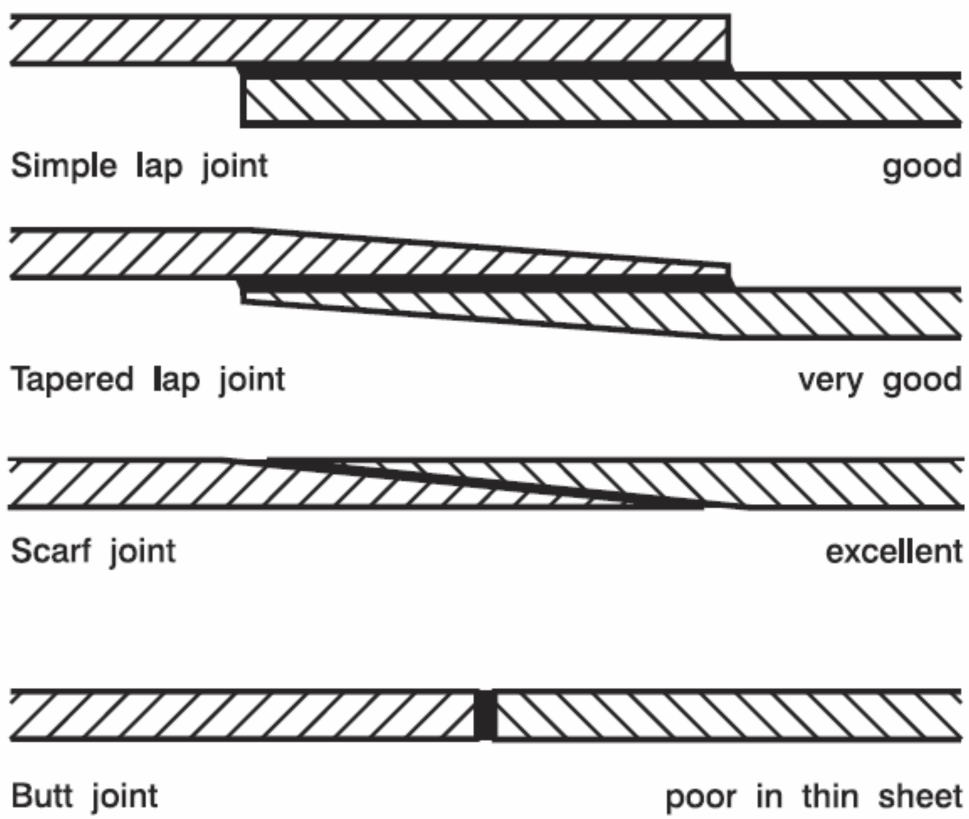
Compare Bolted and Bonded Joints

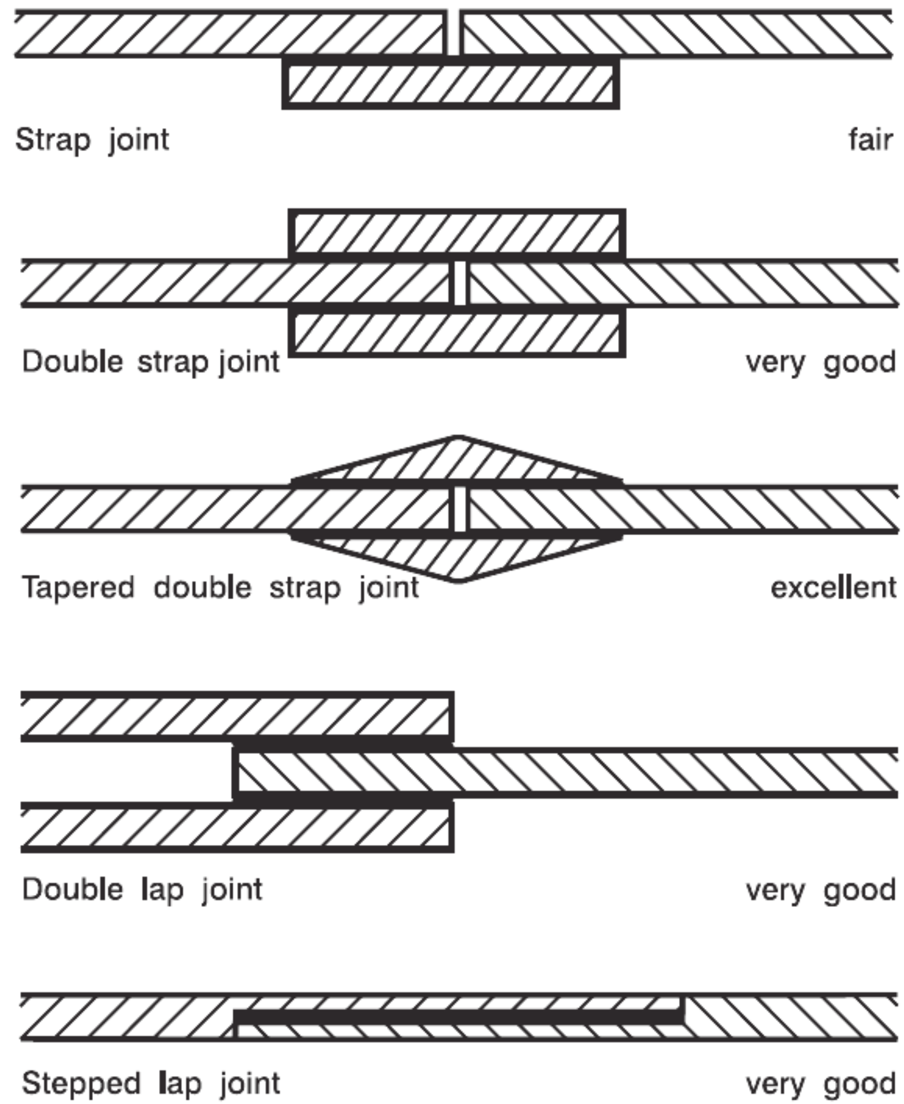




- Bonded joints avoid stress concentrations at bolt holes
- More surface area is involved with bonded connections
- Bonded joints not subject to corrosion degradation
- Bolted connections are easier to inspect
- Requirement to disassemble structure for maintenance may dictate use of mechanical fasteners
- Mechanical fasteners need less accurate part fit-up
- Careful design of bonded joints is critical to avoid peeling

Guidelines for Bonded Joints



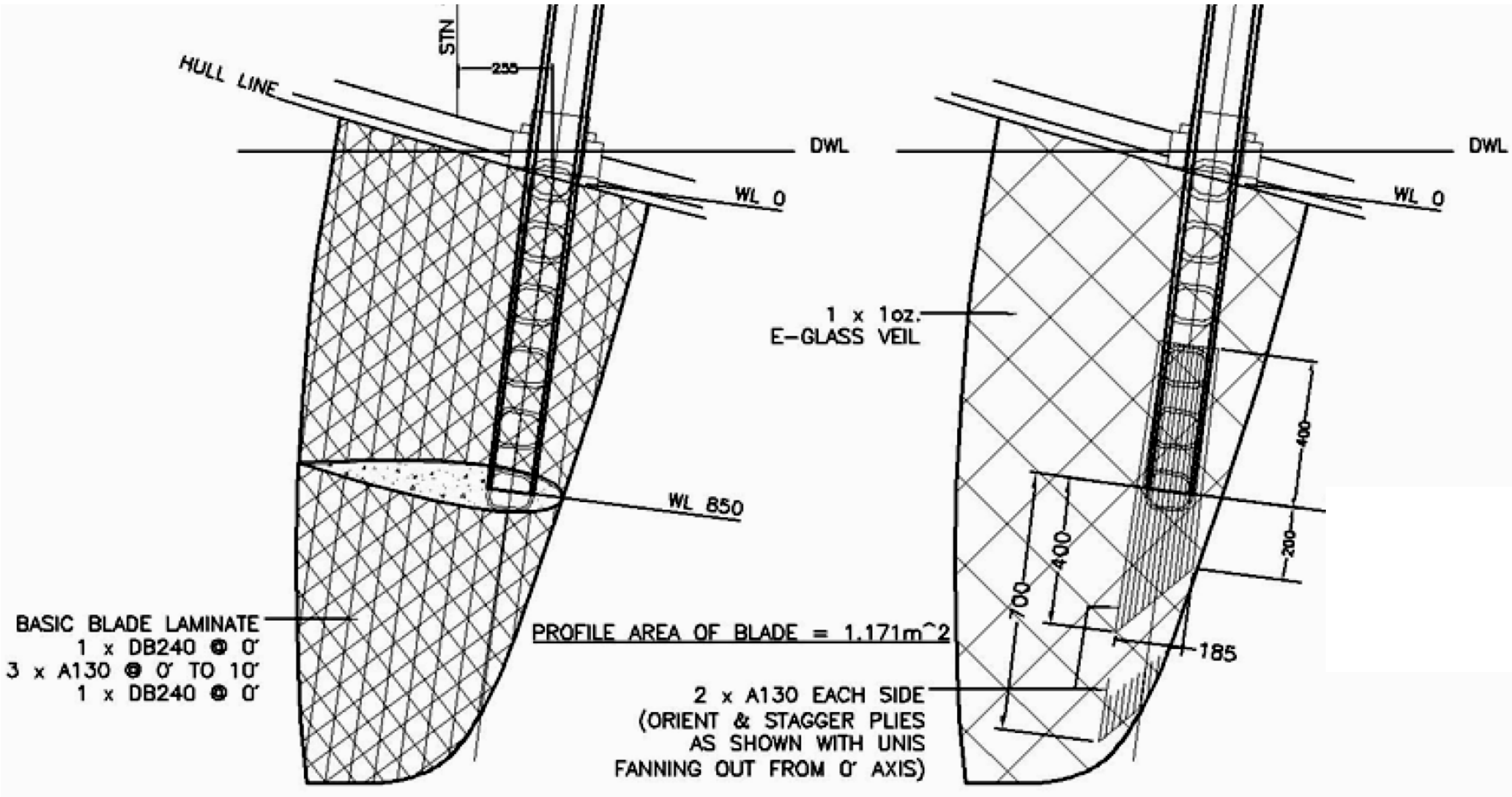


From Redux Bonding Technology, publication RGU 034c, July, 2003, Hexcel Corporation

Joining Technology Summary

- In-plane strength of secondary bonds can never match the primary laminate
- Automation techniques not as mature as metal construction
- Surface preparation, laminating environmental conditions and worker skill significantly influence the strength of composite material structural joints

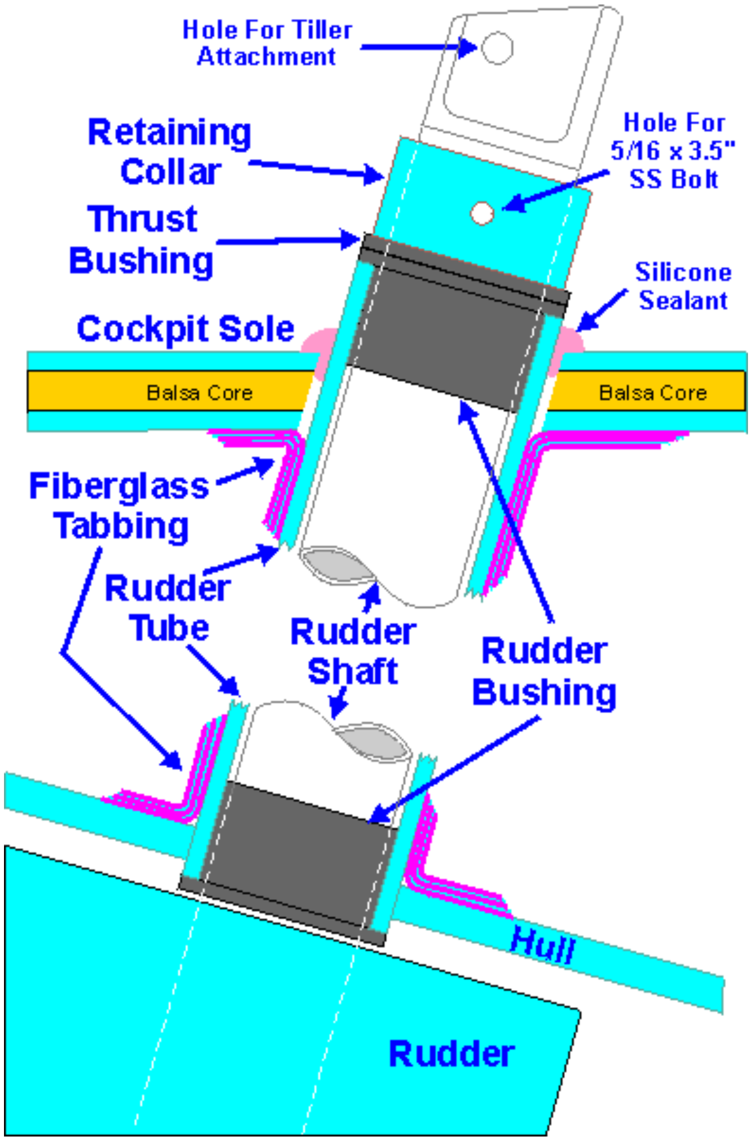
Spade Rudders



David Pedrick & Gram Schweikert, “Design of the Navy 44 STC MKII,” Annapolis, MD, April, 2005

Rudder Bearing Support

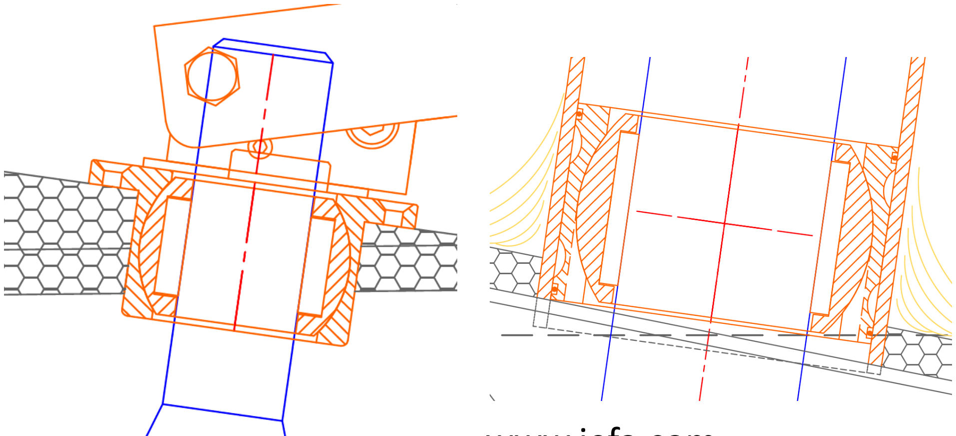
Pearson 26 bearing attachment



http://dan.pfeiffer.net/p26/r-asem.gif

J42 rudder bearing attachment

Recommended Jefa bearing installation detail for tiller steering

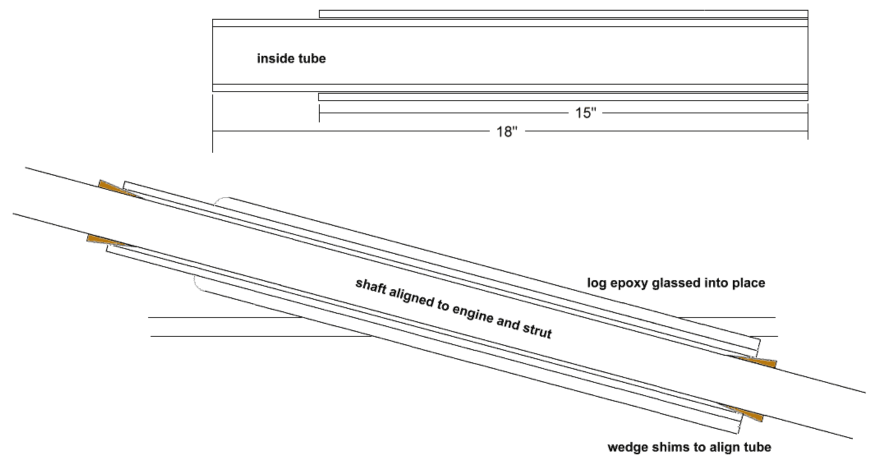


www.jefa.com

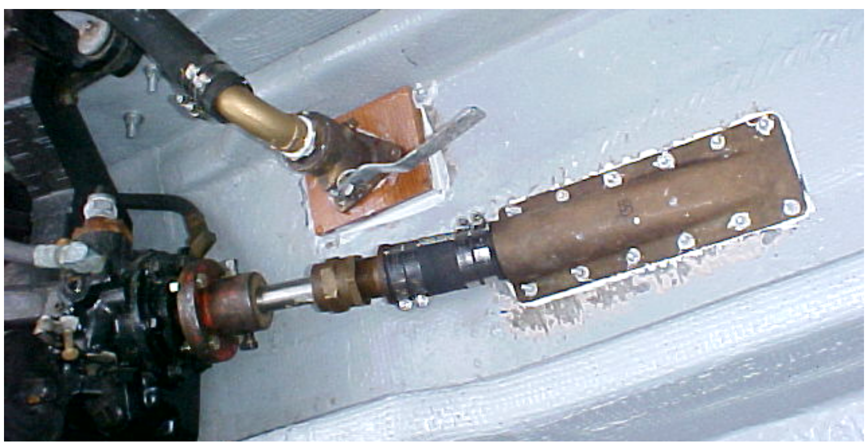
Shaft Logs

Installation Examples

Suggest method for aligning new shaft log installation



Metal Shaft Log



http://www.bertram31.com/proj/tips/shaft_logs.htm