The Herreshoff Rules for Construction of Wooden Yachts - The Modern Context of Significant Classic Advice

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Background

On January 19, 1928, the New York Yacht Club officially adopted the *Rules for the Construction, the Scantlings, and the Other Proportions of Wooden Yachts*, Nathanael G. Herreshoff, 1927 (known as the "Herreshoff Rules"). At the request of that club, of which he was an honorary life member, Nathanael Greene Herreshoff (NGH) had codified into ingenious tabular form his derivation of structural proportions for yachts.

Use of these rules soon evolved to guide construction of wooden yachts over the next 50 years. They are equally applicable today for either new construction or as guidance for careful and accurate restoration of Herreshoff or other yachts.

Subsequently, other formulations evolved for the same purpose. Notable was the Nevins Rules (*Nevins' Scantling Rules for Wooden Yachts*), quite similar, but somewhat more conservative (i.e. heavier scantlings). The similarity was understandable, particularly because, as a young man, Rufus Murray, foreman at Nevins of City Island, had developed his talents working at the Herreshoff Manufacturing Company (HMCo).

Lloyds Rules, a later still more conservative formulation, guided yacht building in England and worldwide. That

Nathanael G. Herreshoff

rule set scantlings of wooden America's Cup 12 Meter yachts and many other constructions in the latter years of conventional wooden boat construction.

Captain Nat's accolades for the successful products of the Herreshoff Manufacturing Company of Bristol do not in themselves reveal much about the strikingly efficient techniques for his prodigious accomplishments. While Herreshoff yachts to this day are admired for the logical grace of fair lines and their performance, looking back, now about a century later, experts in the field attribute excellence of structural design as a compelling factor in Herreshoff's success. I have several times heard Olin Stephens assert that Herreshoff's ability to design and build light rigs that stayed aloft was key. Appropriate is a similar observation about every element of the weight efficient Herreshoff hull structures.

Some practitioners have criticized the resultant proportions of Herreshoff Rules as too light, perhaps lacking strength. Admittedly, a Herreshoff boat is lighter in hull structure than a similar craft built to Nevins or Lloyds. Several observations are relevant. NGH, himself in the text of the rules, refers to the availability, selection and placement of first class wood; at the HMCo the very best woods, much from original growth were procured. Without particular regard for stocking costs, these woods were stockpiled purposely for seasoning, often for years. A specific example is that timbers of "South County" white oak were stocked in the brackish waters of a Bristol creek for up to four years before steam bending into ribs of yachts. Furthermore, the craftsmen of the HMC were the very best in skill, experience and dedication to the work. The best craftsmen of today are as good and have a new advantage of hindsight by observation of venerable yacht deteriorations, but it is fair to recognize that fine as today's best craftsmen are, they cannot match the Herreshoff efficiency. The HMCo employed a remarkable production technique with NGH guiding all work via morning and afternoon tours of the shops each day.

Particularly satisfying is that, while doubtless NGH had no intention to build for a century of use, I, his grandson, race the 100 year old Herreshoff sloop BAMBINO (HMC #616, 1904). My crew will testify that we never baby this baby and we seldom experience trouble. Another proof of the efficacy of Herreshoff scantlings is my NY40 yacht, RUGOSA (HMC #983, 1926), which recently completed a 24,000-mile voyage including two transatlantic passages without any serious trouble; more about her construction will follow.

Elements of Yacht Structural Design

Before looking at the precise specifications of the Herreshoff Rules, let us devote attention to the general elements of yacht structural design. What is required and how are the needs met?

Both girder strength (bending) and local strength (deflection or puncture) require consideration. The former is particularly relevant to the longitudinal stiffness (contrary to bending deflection) of the entire hull with its loads of keel weight, mast column loads, standing rigging tensions, uneven buoyancy in large seas, and dynamic loads (this latter generally less severe than commonly suspected). In the vertical direc-

RUGOSA - Sailing by the temple to Poseidon, Cape Sounion Greece 2004.

tion girder strength and stiffness must resist the opposing couples of sail loading to heel and keel loading to right a yacht.

Generally provision of scantlings to satisfy these needs also provides sufficient provision for local deflections or puncture. This may not always be the case. In particular, at hard spots (i.e. adjacent to extra firm abrupt support such as at web frames or bulkheads) some extra back up structure may be necessary. Such considerations are, of course, equally applicable to any structure or vehicle including state-of-the-art composite constructions.

Introduction to "The Herreshoff Rules"

When first contemplating this paper, I pictured setting forth guidance for interpreting and using the NGH Rules. I've decided that really is not necessary because the presentation by Captain Nat is totally sufficient, presented in his inimitable succinct, direct way. Certainly, I could not improve on that. And the rules themselves are timeless.

What I will do is follow this tabulation and example of rule use with observations about the merits and problems of wood, metal, adhesives, and practices. Except for wood, these materials are today available in improved form in most instances. Optimizing selection and use of them requires thought and common sense. For method, it is important that we do not lose the acquired knowledge of generations of builders lest we must "re-invent the wheel."

Before studying the details of these wonderful rules, it is worthwhile to appreciate how they came about. Of course, it was only because the HMCo had produced so many race winners for New York Yacht Club members that the club requested Mr. Herreshoff to write a summary of his engineering deriva-

BAMBINO

tions. At that time he was nearly eighty years old, still designing, and in possession of notes concerning hundreds of designs. He had the confidence to tackle any engineering challenge. His methods were orderly and efficient. He liked to go all out to utilize theory, experiment, and experience to solve a design problem. Often the result was a drawing or sketch with a table of dimensions for each proportion of a series of items. Since in practice, utility and structure do not scale equally, the items in a series were not geometrically similar but were instead interpolations of a few particular sized items comprising benchmarks for the series. For example, he designed anchors and tested them by having teams of mules pull a spring dynamometer attached to the rode of an anchor dragged through the turf of beaches of various compositions. These experiments taught both the optimum shape for good holding as well as mechanical proportions necessary for strength of the anchor. There are similar tables for cleats, chocks, spars and other standard components of a yacht.

The Herreshoff Rules presented here are exactly the same thing applied to the whole yacht structure, not just to one detail. Again yachts of different sizes do not have geometrically similar proportions; hence the complication of the tabular method to define optimums at each size of boat. Though a first look at "The Rules" may be daunting, once studied, they seem logical and simple to apply. For that, do concentrate on the example Captain Nat provides at the end of his presentation.

Some years ago, the late naval architect Francis Kinney included the Herreshoff Rules in a book about yacht design (Skene's *Elements of Yacht Design*). Frank's comments, reprinted on the following page, is a fitting introduction to the NGH rules.

Observations on the Applications of "The Rules"

The structure of a yacht faithfully constructed to the Herreshoff's Rules for Wooden Yachts can last longer than the lifetime of the owner. However, it is worthwhile to consider certain basic considerations from analysis and observation:

1. **Steam bent frames**– The biggest problem is stretching of outside fibers, sometimes to the point of rupture of oak frames curved too sharply when steamed. Extent of steam penetration, speed of bending and technique are vital. But even with good proportions, best wood and best practice, there is a limit to the advisable extent of bending. Small radii of curvature are to be avoided. That at the bilge of a boat designed with sharp curvature there is a definite challenge. The sharp bends sometimes made near the lower portion of a "wineglass" shaped hull are avoidable. A neat trick is to simply not bend so much after the frame begins to juncture with the vertical floor. That is, rather than screwing the garboard plank and perhaps its neighbor to the bottom of the frame, fasten it into the floor such that the bottom of the steam bent frame connects to the floor further inboard, thus preventing the otherwise too small bending radius of the frame. Another solution employed more today than in yesteryear (after observation of old ruptured frames) is to "kerf" the steam bent frame. This practice means precutting the stock to be steam bent only so far up from the bottom to include sections that will be sharply radiused in bending. The cut is made approximately along the neutral axis, as thin and straight as possible. Thus, that portion of the steam bent frame can permit natural slippage along the original neutral axis during bending. It is as though bending two adjacent thin beams rather than a single thick beam; the easing of tensile stretch in the two separate leaves is remarkable. However, kerfing can pose some problems. It is vital to reconnect the two leaves of the kerfed frame in order that the combination exhibits the necessary structural stiffness at the lower portion of the frame. This can be achieved by gluing or mechanical fastening to resist the sheer at the neutral axis of the reconnected beam elements. The former is difficult to accomplish because of trouble to properly apply glue into the tight cut plus the fact that oak really does not glue very well. The latter just requires judicious and sufficient fastening with large enough screws usually through the planking extending to beyond the faying surface.

2. **Fit**- The virtue of good and accurate fits between wood members cannot be overemphasized. Both for structural connection and also for exclusion of dirt and possible fresh water, principally during lay-up, there is nothing like perfect fits and sufficient fastening at connections of wood elements. Just stuffing in filled epoxy or other filler does not succeed as well as good craftsmanship. This lesson is constantly evident in examination of old construction or especially shoddy restoration techniques.

3. **Strapping**- NGH. pioneered the employment of diagonal or body strapping set forth with emphasis in his rules. The purpose is to prevent the racking characteristic of any planked structure (including old barns). Particularly when

a boat is relatively dry in the early season, planks under load may slide imperceptibly along each other allowing the structure to rack. The dimensional alteration is not the only problem; successive cycles can wear wood elements, loosen fastenings and certainly shorten life of the yacht. Diagonal straps must be properly placed, well fitted and sufficiently fastened. Securing at the ends is vital to ensure full effectiveness. The body straps were for the different purpose to enhance tensile strength of the bottom of a hull with relatively low ratio of depth to length. Decks were similarly strapped, but this is unnecessary for decks built of plywood or having an under layer of plywood. To be effective in preventing racking, it is best to employ successive plywood sheets connected by gluing rather than using single thick sheets difficult to join rigidly. Well-connected plywood panels will not rack. Stress corrosion cracking of keel bolts can also be a problem for diagonal strapping. This is particularly true of outside keel straps for enhancing connection of lead keels as in S boats and other Herreshoff sailing yachts. Very unfortunate was the practice of the HMCo in its latter days to substitute galvanized steel for bronze in hull diagonal strapping, these steel straps in hull and deck have rusted away in many applications eliminating the needed racking support and also causing severe damage to wood in contact with the rusting metal.

4. **Butt blocks**- Butt blocks are often problems in older boats brought in for overhaul. They need to be oak, well fitted, and through bolted to the ends of planks connected. The blocks must be sufficiently long longitudinally for effective connection and transversely to prevent leaking around the corners of the connected planks. Quite often butt block bolts are found insufficient, deteriorated or damaged. An additional consideration in fastening new butt blocks is to make them a dimension just short of the frame space in which they are fitted so that bilge water and especially fresh rain water through a leaky deck can drain away promptly to avoid dry rot.

5. **Limber holes**-This brings to mind the vital importance of providing sufficient limber holes in the corners of replacement hull vertical floors; all too often this need is neglected in replacement fabrications. A clean bilge with proper limber holes assisted by a pull chain running through the limber holes fore and aft benefits longevity of a hull.

6. **Cold-molded**- Molded plywood hulls (not addressed in the Herreshoff Rules) can be good construction if layers are properly connected without gaps and with thorough gluing. The result has the advantage of much greater hull belt strength than a carvel-planked hull. No diagonal strapping is necessary because the molded plywood hull cannot rack any more than the plywood panel deck described above.

7. **Glues**- Modern glues are greatly superior to the "hot" glues or "animal" glues of the past. This is one reason why NGH employed glues as little as possible (but to a large extent in spars). While acknowledging the value of fine modern glues, one should convey the admonition that it is bad practice to think that sloppy poor fits can be corrected by just filling voids with glue. Also, the prevailing notion that epoxy glue can totally seal wood parts is often

naive. Water will find its way into wood structures if there is the slightest crack in epoxy sealing; such cracks even if not present in new construction will develop in time.

8. **Mast steps**- While the original Herreshoff mast steps were generally adequate, it is a good idea to make replacement mast steps a frame space longer fore and aft to enhance spreading the load. Another important provision is to add a tensile rod each side from under the mast step up to connection at the clamp. This latter connection is vital. The practice of sometimes fastening the upper end of the truss rod to planks part way up the side is bad, yielding poor mast support and overstraining the planking. After proper connection to the clamp, it is generally advisable to add an effective wood or tubular metal compression member running athwartships the hull, separating the connection points where tension on the rods has induced severe transverse compression of the deck.

9. **Bilge stringers**- NGH did not generally employ bilge stringers considering them less necessary structural elements than others parts. There is a case for bilge stringers to absorb unwanted stress concentrations, in some cases, such as where transverse structural elements may end.

10. **Watertight decks**- Fresh water is the curse of wood boat construction. Vital is a watertight deck. A terrible practice is that of sometimes running frame ends through the deck edge covering board to support bulwarks. Such a connection always leaks; this construction feature will never be found in a Herreshoff yacht.

11. **Properties of structures**- A word about the general properties of structures is in order. Generically an infinitely stiff structure will in theory generate infinite stress, which would, of course, cause failure. At the other end of the spectrum, weak structures allowing large deflections don't accomplish the job either and can generate high stress to failure of structural elements loaded by deformations. These considerations accrue from properties of structural materials as well as the design of their employment. If all is well initially, then fatigue failure may become the issue from long-term cyclical loadings. Certain high modulus metals exhibit improper vulnerability to fatigue in practice. This is a very serious consideration in big ship construction as well as for airplanes and really any structure subjected to high cyclical loading. A great virtue of wood is its seeming lack of vulnerability to fatigue failure; how many stress reversals might be counted in a one hundred year old tree subjected to cyclical bending from ever present wind? So our venerable wooden boats are far less likely to fly apart from fatigue than may a metal one or an exotic carbon hull of light proportions. This is interesting and a satisfaction to one weathering a storm in the ocean aboard a classic wooden yacht.

Wood

The favorite Herreshoff woods were:

White Oak - Good white oak possesses the best qualities of strength, resistance to rot (but not much resistance to marine borers), steam bending, and ability to hold fastenings. These attributes make white oak the choice for frames, floors, keels, deck beams, and other substantial structural elements.

Ash – An outstanding structural wood but not as versatile or resistant to rot as white oak.

White pine – Nat Herreshoff's favorite for making his design half models and for planked decks and other elements of yachts. But pine decking, while beautiful and great under foot, requires much upkeep work and it is a challenge to make such decks truly watertight.

Spruce – Exhibiting the highest strength to weight ratio, spruce is the choice for smaller spars and is a wonderful wood to work.

Cedar - One of the best woods for strength to weight ratio and ideal for planking of small yachts including lap strake dinghies – easily and agreeably worked. About the only disadvantages are softness (low resistance to denting) and relatively large dimensional change between dry and wet. Eastern white cedar was preferred at the HMCo, but Port Orford cedar and Alaskan Yellow cedar are also excellent.

Yellow Pine – If from good growth, absolutely the finest possible wood for planking for all except small or especially light yachts. Yellow pine has exceptional structural properties, only moderate swelling in water, good resistance to marine borers and incredible durability (Taking a hole saw cutout from 70 year old planking shows original sap still running from the cut surface).

Cypress – Used for inner planking of double-planked vessels for reasons of weight, strength, and availability. Cypress can be found clear and is a good wood to work.

Douglas fir – A fine medium weight wood sometimes available in long straight knot free form making it ideal for larger spars and important structural elements such as bilge stringers.

Butternut – The standard interior joinery wood in Herreshoff yachts – mostly clear, light, easily worked, and of pleasing color.

Mahogany – Real mahogany (not the Philippine variety which technically is not mahogany) is considered the finest looking wood for joinery above or below decks. A disadvantage for on-deck mahogany is that varnish must be kept sufficiently built up to prevent wetting of raw mahogany lest it blackens from the moisture. Great mahogany is getting scarce and expensive.

Teak – A harder, denser wood that also can be beautiful when well finished and left bright. Having ample interior oil, teak does not severely blacken when exposed to water. The best look for teak rails etc. is when it is properly varnished. Teak also has admirable structural properties and sufficient hardness making it suitable for rub rails, stems, keels, etc. Cost is becoming ridiculous. A further disadvantage of teak (shared with oak as far as epoxy is concerned) is its inferior quality for gluing; this is a direct result of its otherwise beneficial oily content.

Metals

Metal for fasteners and other structural elements:

My father, Sid Herreshoff, was not one to criticize, but on several occasions, inspecting other boat constructions, he pointed out the error of using too few and too small fastenings. This is particularly obvious in the attachment of fittings such as chocks and cleats – sometimes fine strong fittings are too easily torn from the deck because of inadequate fastening. The same defect is evident in some hull constructions observed. Of course, a caveat is that the choice of fastenings must depend not only on their strength and holding power but also upon consideration of the impact upon structural wood elements such as frames. It is a mistake to monopolize too much of a frame by excessive fastening or too close placement of in-line fastenings that may induce splits from one to another. For this reason, except in small craft, it is not best practice to rivet or bolt planking in place through frames.

The traditional metal for fasteners was manganese bronze. Mechanically good, manganese bronze suffers severely from galvanic corrosion losing essential elements of the alloy (dezincification). We have all seen old diminished reddish wood screws that crumble to oblivion when attacked by a screwdriver. Tobin bronze was the standard for structural parts such as strapping and shafting. Phosphor bronze is a good, but more expensive alloy especially suited for fittings such as tangs and straps. The advent of silicon bronze (Everdur) before World War II was a great boon as examination of old, but once restored yachts proves. Silicon bronze should be the choice for replacement hull fasteners.

It is conventional for experienced wood boat builders to shy away from stainless steel fasteners from concern about the conjunction of dissimilar metals in water – i.e. stainless steel and bronze. Perhaps this concern is exaggerated, especially if one is careful to provide sacrificial zinc anodes. After all, it has become common practice to use stainless steel shafting and other underwater elements in conjunction with sealed in bronze fastenings without demonstrably bad result.

Type 316 stainless steel is preferable to type 304 especially in parts visible as on deck. Also, regrettably some stainless steels, especially from abroad, are clearly not fully “stainless” today. Type 17-4ph is correctly touted as strong and stiff. It should not be used in salt water. Some years ago just before a Bermuda Race, a 17-4ph spade rudderstock on one of my boats developed an alarming and dangerous crack such that it had to be replaced in a big hurry.

Aside from the aforementioned galvanic deterioration of old bronze, the greatest problem in marine fastening is stress corrosion cracking. I shall never forget a finding while conducting the 70-year overhaul of my New York 40 RUGOSA. The 1 1/8” bronze keel bolts were observed to be in perfect condition except that every one had a hairline crack across at the position of the juncture of the lead keel to the oak wood keel. Just consider that every tack and even each of the millions of stress reversals as the yacht lurches in a seaway cause a bending stress reversal of the keel bolt. Just as the familiar bending back and forth of a coat hanger can break it, a similar phenomenon exacerbated by simultaneous galvanic corrosion will eventually cause failure of a keel bolt or other alternately loaded part.

A Case in Point by Way of Example.

The study and application of the Herreshoff Rules can safely guide new or replacement structure of a wooden yacht hull. This may totally guide replication of earlier designs, new wood designs or restorations. For a museum restoration purpose, it is best to avoid doing too much. Obviously, a museum should try to present a boat as original as possible, replacing deteriorated components while retaining as much of the original fabric as possible. One should try to avoid the seemingly easy practice of scrapping some good wooden part to replace it with new wood (that just might be inferior to the original wood). But for practical restoration for safe sailing, some deviations from pure adherence to the original may be appropriate. By way of example, I shall now describe the reason, philosophy, and practice of restoration of my Herreshoff New York 40 RUGOSA. Having a strong desire to safely sail the world's oceans, I recognized the challenge to accomplish necessary upgrading on a limited budget. Many elements of the yacht had deteriorated after seventy-five years of sailing. We replaced the stem, part of the keel, horn timber, garboards and some other planks. Some unusual solutions were accomplished by two master builders, Fred Dick and Bob Cunningham along with Bob's wife Mary. These remarkably skilled and dedicated boat builders put their all into restoring my RUGOSA in preparation for racing and a 24,000 mile cruise. I shall always feel intense gratitude toward them, especially when weathering a gale in the North Atlantic or a Gulf Stream thunderstorm.

1. Frame to floor connections – Some of the floors needed doubling or replacement. Although one of the most serious problems was deterioration of the connection of frames to floors, I did not have a budget to replace all floors and all frames. Instead we constructed laminated mahogany framing elements reaching continuously across above the keel and reaching about four feet up each side. These were well fastened to the floors on the opposite side from the original frames. To avoid stress concentrations at the ending of these stiff partial frames, we provided a laminated continuous Douglas fir bilge stringer each side at the terminus of the auxiliary frames. This produced a wonderful strong structure, stronger and more reliable than the original but at the expense of extra weight.

2. All diagonal strapping had rusted away. These straps running between frames and planking are very difficult to replace without petty much taking the boat apart which I did not want to do. The deck had already had a plywood layer added which obviated the need of a set of replacement deck straps. This suggested to me a simple solution for the missing hull diagonal strapping. That was to replace the original planked ceiling on the inside of frames with a molded plywood glued ceiling continuous fore and aft and thoroughly fastened to the frames. This has worked admirably in totally resisting hull racking while also providing all or more of the function of the original ceiling.

3. The mast step had cracked underneath – We replaced the mast step with new wood of nearly identical dimension but a little longer. The new mast step included a bronze sheet screwed underneath to absorb the under side tension in the mast step when subjected to considerable bending accruing from the down thrust of the mast.

4. Replacement steering. The original yacht had a small diameter wheel driving Captain Nat's ingenious and simple steering device employing a bevel geared drive. The long term trouble with the fitting is that wear of the gears is greater near the center of travel than at the ends. Thus if the spacing of the gears is set by the middle range, there is no way the outer gear teeth can mesh without locking up from too tight spacing. Conversely setting spacing according to the outboard gear teeth leaves the middle too loose causing annoying middle range back lash. The only apparent solutions were to remachine the gearing or to replace the unit; I chose the latter. We now have an Edson Steerer installed with light but efficient metal structure about the pedestal drive and rudder head.

5. Taking a lead from a much larger yacht that we restored some years ago, we replaced the chainplates by securing them not on the inside of the planking but to plating established on the plane of the inside of the frames. This permits reliable structure not impacted by the deterioration of the old holes for bolting chainplates to the planking. A useful byproduct of the change is moving the chainplates inboard enough to facilitate new and better chainplate covers sufficiently inboard of the toe rail to function well.

6. And, of course, we added self tailing winches even though they are penalized in the European classic yacht racing circuit.

7. To enhance support of the mast, I changed to a two spreader rig with all fore and aft stays identical to the original. New spreaders of ash are not very different from those designed by my father, Sidney Herreshoff, eighty years ago.

8. As original yachts designed to the Herreshoff Rules had small factors of safety, it is worthwhile to consider differences in loading between say 1926, when RUGOSA was built, and 2006. Differences accrue from modern flat non-porous sails, higher tensions on headstays, running backstays, and main sheets plus generally more aggressive race sailing in these times. Fortunately athwartships rig induced maximum loadings are just a function of yacht stability (the righting couple). The keel and vertical center of gravity are little changed so that stability is only a little different from a modest increase of total yacht weight. Thus, the limiting magnitude of the righting couple is for practical purposes the same as is its resultant atwartships loading. But the longitudinal loading on the hull is significantly increased by the increase in tensions on standing and running rigging. Thus, there is a tendency to induce permanent deformation of the fore and aft hull shape and locally at such positions as the attachment of running backstay fittings. A specific example aboard RUGOSA is the attachment of the bobstay to the stem. There the original fitting threatened to pull out. My solution (perhaps overkill) was to extend the fitting 22 feet aft in a stem strap lag bolted into the lead keel. The fitting is no longer any worry.

Otherwise, RUGOSA is just as original and shares with us her original sailing qualities enhanced by modern Dacron and Nylon sails.

Other Applications

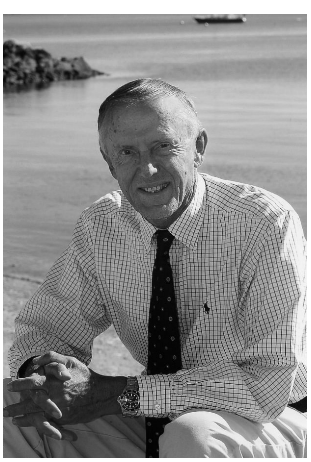
The Herreshoff Rules and this discussion are directed to wooden boat construction. But lessons herein are to a considerable degree applicable to any structural design – i.e. boats of other materials and also to structures for other purposes than waterborne activity. Always the objective is to provide adequate strength for service without failure while minimizing weight and cost. The considerations of stiffness or flexibility, puncture resistance, and problems of brittle or too-forgiving materials are universal. Good design is generally the most simple and straightforward solution. Any good engineer is thrilled by an elegant invention

Steel or aluminum hulls are clearly advantageous for larger craft, but have their own set of problems from welding stress or the possibilities of crack propagation. Graphite sandwich constructions provide incredible strength and stiffness to weight ratios, but suffer constant fatigue degradation of the bond between skins and cores. Also, these high modulus thin structures are susceptible to puncture. The point to be made is that just as size motivates scantling selection, so does material choice demand analysis for optimization.

We live in a time when technological advances continue apace. NGH, if alive today, would express both amazement and delight at adhesives able to secure high stress items like chainplates without mechanical fasteners. The efficacy of deep short keels (originally pioneered by Nat Herreshoff in 1891) depend upon the speedy sailing of boats with high sail area to weight ratios and upon the good qualities of modern materials to secure the cantilever keel fins.

We all advance by taking a step beyond that which is known. The speed of progress is abetted by the instant communication of our time. Those of us who engineer structures are riding on the shoulders of the giants of the past like Captain Nat Herreshoff. So study "The Rules" both to directly apply them to wooden yachts and also as grist for invention of any structure of any material.

About the Author:



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