The SHOCK of the OLD

Photograph Kathy Mansfield.

Part 13: MAKING CONNECTIONS

Moray MacPhail resumes his series on refining traditional rigs by analysing their components and the loads they bear..

So far then we have rigging with terminals and a place to attach them to the spars. What about attaching them to the hull?

Chainplates

Last time we saw that friction alone is unlikely to work on wooden spars. The same is true for hulls since the crush strength, even of a wood as hard as oak, is about 6MPa compared with the 4MPa for spruce. Doing the sums for a 4mm (3/16") wire with a break load about 1 tonne leads to a plate size of around 225 x 40 mm (9" x 1.5") held on with three 6mm (1/4") bolts or two 8mm (5/16") bolts.

The bolts sound about right but the plate does not seem practicable: you would never have such a large plate for 4mm wire, held on with just a few smallish bolts. So it is not really feasible to rely just on friction when attaching chainplates to wooden hulls. On the other hand, loose bolts provide no friction and would be almost as bad because the bolts being pulled sideways would crush the wood around them and work loose.

So just like plate mast furniture, chainplates need to be held on to a wooden hull by both fasteners and the friction between plate and hull which comes from tightening them. A reasonable compromise which seems to work in practice is to take half the load by the friction from the plate, and half by bolts in shear. In this case, you would have a plate of about 150 × 30mm (6" x1 1/4") attached with two 8mm or three 6mm bolts. Bolts are preferred to screws because they can be tightened to take up any slack. Sometimes, the uppermost hole is often fastened by a screw because the beam shelf or rubbing strake in that area limits the access. It is best to discount the effect of this screw when totting up the fasteners required

To sum up for each tonne of design load, you need 450mm^2 of effective contact area held by 120mm^2 of bolts based on their nominal diameter.
On wooden hulls of carvel or strip construction, the length comes from the required area and an aesthetically acceptable solution. On clinker craft you will almost certainly need to extend the length required to align the chainplate ends at or near the lower edge of one of the strakes or bulk out the shape to fit under a strake.

On steel or GRP, where you can weld or bond, you can have pretty much any shape you like so long as there is enough weld metal or resin. In these cases the crush strength of the material is not an issue – unless it is a foam sandwich build.

Left: *Channels spread the load on an 1880s Nicholson design.* **Right:** *Chainplate on a clinker International 12 dinghy.*

Sometimes the stays need to clear bulwarks. The options here are to fit channels or extend the chainplates themselves up through the bulwarks. Channels have the useful advantage of widening the shroud base, so reducing the shroud loads – see W142. Though they may be vulnerable when coming alongside, they do provide an excellent place to locate those boat legs much favoured by sailors in areas of hard beaches to allow the vessel to dry out without falling on its bilge,

Running the chainplates up through the bulwarks, on the other hand, keeps all inboard and means that the rigging screws or whatever start above bulwark level. While I cannot see any technical objection to this arrangement – the logical extension of which is rod rigging – I have to admit that aesthetically I really don't much like it.

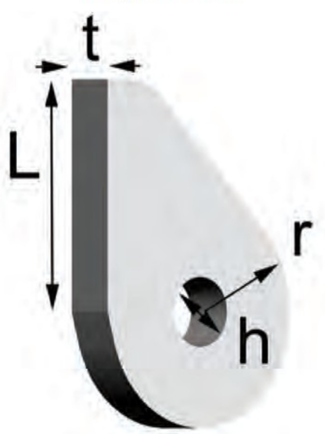
FIGURE 1: Dimensions for lugs on mastbands based on wire size diameter d in millimetres

Thickness, t = 1.5 x d

Hole diameter, h = 1.5 x d

Outer radius, r = 3 x d

Length, L = 4 x d



Making the connection

Both mastbands and chainplates will need lugs. For a given wire size, the dimensions in Figure 1 should be a little stronger than the stays themselves. These will work with standard fork-end terminals and suitably sized rigging screw ends. It is normal for the upper part of chainplates to be thicker than the main body, so local reinforcement may be needed. It is also helpful if the lug lies fore-and-aft to reduce the work that a toggle has to do by bending the lug to align with the stay.

You don't have to use a pear-shaped lug but the key dimensions, such as radius and thickness, coupled with the caution that the attachment should be stronger than the wire, means that the material must be of a certain strength. Most wrought materials – steel, stainless steel, phosphor bronze,

A rigging screw horror show L to R: *At the end of the tether; Rusty threads, top one seized; Locknuts are for wimps.*

aluminium bronze, for example – are strong enough. Some cast materials are not, partly because cast metals – particularly the various yellow metals – are weaker than their wrought equivalents and partly because however good the casting, you must make allowances for potential defects in the material. For example if you have standard fork ends at the upper end of your stays and the stays are correctly sized, it may be better to have a mastband fabricated from wrought material.

There are ways round this. You could use eye terminals on the wire and one lug each side of the eye. This is quite often used in fabricated mast fittings, which can then be made from thinner material. Whatever lugs you use, they should be attached to a band or plate made from material of at least half the thickness of the lug, so that the loads on the lug can be transferred.

Shackles

So far, so good. Now we'll connect the wires to the hull or spars. Without inflicting a long table of shackle strengths on you, it boils down to multiplying the wire size by about 1.2 to 1.5 for stainless steel and by 2 for galvanised shackles.

I'm assuming here we are using the cheap galvanised shackles usually on offer in chandleries, rather than the green pin rigging shackles which are a good deal stronger.

It is likely that a quick inspection of your nearest boatyard or marina will provide a number of examples of undersized shackles connecting stays to hull or spars. While it may have the advantage that you know where a failure is going to occur, such an arrangement is risky to say the least. But if you worry that shackles are maltreated, look at what they inflict – above – on the poor rigging screw.

Tensioners

Now we have stays and connectors on the mast and hull, all that's left is to tension them. The most common solution is to use rigging screws. which are very effective and come in a range of styles.

Galvanised rigging screws are cheap, usually closed body, need greasing for protection – anhydrous lanolin is superb for this – and will rust horribly before actually breaking under normal service loads, so you get plenty of warning. Stainless steel ones are less cheap, usually closed body, can spall – where the threads seize together – if not greased – again lanolin helps here – and can corrode out of sight – or rather out of oxygen. Bronze ones are even less cheap but are 'fit and forget' items. Unless broken by an abnormal load – often during mast stepping – they last more or less indefinitely. You can also get

Uses for aluminium low friction rings – of which more in future episodes. Illustration: Holt Marine Ltd.

rigging screws which use a chromed bronze body with stainless terminals which overcomes the spalling problem. Finally, while we are discussing bronze rigging screws, there is a range made for smaller boats which are shaped to allow hand tightening. This comes into its own for trailer sailors, especially those who forget to bring their tools

Whichever type of rigging screw you choose, be sure to put locking wire on and/or tape over the split pins. Please also check the actual breaking loads – galvanised rigging screws in particular can have very different ratings. In round numbers, stainless rigging screws should be 1.5 times the wire diameter – say a 12 mm (½") screw for 8 mm wire – and twice the wire diameter for galvanised.

What about other options? Rope lanyards or lashings cost as many pennies as rigging screws do pounds. The table shows how many turns you need of a particular rope size to match the strength of a wire, which is around 3 or 4 turns for polyester. I know that such an arrangement is not as stiff as a rigging screw but for most rigs and uses as explained in W142, that lower stiffness over a short length simply does not matter. But recall from W152 that HMPE is size for size stronger than stainless steel wire. So if you use aluminium low friction rings or thimbles with a turn or two of HMPE – secured by a series of half hitches – then you have a light, strong and cheap solution.

For the real traditionalists, of course, wooden deadeyes are the thing, ideally lignum vitae if you can find it. Though some boats demand deadeyes on aesthetic or historical grounds, deadeyes are no more effective than lashings – apart from reduced chafe. Like wire wheels on cars, they have no technical justification but those who use them surely know how to set 'em up.

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TABLE 2: Breaking Loads (kg) for Standing Rigging Materials

		Stainless	HMPE	Polyester
Diameter	(mm)	1 x 19	7 x 7	8-plait
2.5	500		570	
3	730	550	1000	250
4	1300	1000	2060	420
5	2000	1500	2400	600
6	2800	2000	3980	880
7	3550			
8	4650	3900	5360	
10	7250			
Factor*	77	60	100	25

*The "Factor" gives a rough estimate of the breaking load in Kg when multiplied by the diameter of the rope in mm. For example 6 mm 7 x 7 wire has a break load of 6 x 6 x 60 = 2160 kg

OUR APOLOGIES

In Part 12 of the Shock of the Old, the equation for shoulder size lost its brackets in the editorial wash.

Where it said:

Fmax = 30 x D² – D – 2T²

It should have said:

Fmax = 30 x (D² – (D – 2T)²)