Performance Tuning using Tapered Battens

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The Supernova has a fully battened sail of almost 9 square metres which is very powerful. As a result, the boat is fun to sail and can be very exhilarating in the right conditions. There are occasions especially in lighter winds when we would like a bit more power and boat speed, and some performance tuning of the rig would be desirable. The whole aim of the sail is to develop lift to drive the boat through the water, so it's highly beneficial if we can make some improvements to the sail tuning in some way. Fortunately, although the Supernova is a 'One Design' boat, it is class legal to modify sail battens (but not class legal to modify the sail in any way).

The battens in a fully-battened sail primarily do two things:

1. They affect the aerofoil shape of the sail.
2. They affect the stability of the sail by modifying the sail shape as the sail gets loaded with changes in wind.

The battens should ideally bend in the same aerofoil shape as Jeckells designed into the sail. This means the batten under load should have its maximum bend or deflection somewhere around 40% of the width of the sail at each batten location in the sail. The sail is like an aeroplane wing (an aerofoil) and is designed to develop lots of lift with as little drag as possible.

The standard Jeckells Supernova sail is supplied with relatively cheap untapered battens which are very soft. The battens are 'untuned' meaning that they do very little actual shaping of the sail.

If you examine the battens by taking them out of the sail and bending them you will see they have a maximum draft (the point of maximum camber) of 50% (halfway along their length). Since they are soft they don't do much to force an aerodynamic shape, and the aerofoil shape is defined wholly by the sail cut as defined by the sail manufacturers. This is all very well when the sail is brand new, but as the sail ages, the cloth becomes floppier, the seams less tight, and the sail doesn't perform as well. The camber gets deeper and the maximum draft tends to move aft - some Cunningham is usually needed to bring it forward again. This isn't a great idea as more Cunningham opens the leech at the top of the sail which can lose power in lighter winds.

Modern sails are designed and made with their position of maximum camber between 38% and 45%. As we've seen, without taper the shape is more semicircular with the maximum camber at 50%. When a sail is under wind loading the drive point is forced rearwards. The cut of the sail might put the maximum camber at say 40% but the wind loading can force it to 50% or beyond, especially with our softer battens and older sails. The power of the sail is drastically reduced. Also, the soft battens allow a rounded leech profile so unless you tension the kicker just right, the leech will be hooked and the airflow will more readily stall off the leeward side of the sail, creating turbulence, less lift and more drag. The boat will heel more, and more weather helm is induced, which is slow.

In most respects, the standard battens aren't ideal for our normal sailing.

So why keep using untapered battens?

The simple answer is that you can. Probably 95% of Supernova sailors haven't changed their battens from the standard ones although some have experimented in the past by adding extra stiffening to existing battens. There isn't any information available as to the success or otherwise of any experimentation, nor is there any information on Supernova sail tuning to gain a performance advantage. However, if you compete regularly you will appreciate that a few percentage points of improvement are often all you need to put you in clean air and get in the lead. There is a lot to be gained by tuning your sail to give yourself a small advantage. Although we are not allowed to modify the sail, we can do this with the battens.

If you take a standard batten out of your sail and bend it, you will see that its natural bend or curvature will be symmetrical about the batten midpoint - 50% chord. Now we see a conflict between the way the untapered batten naturally wants to bend and the aerofoil shape Jeckells hopefully built into the sail. So, what are we going to do? Mmmmh, a bit tricky this one ... maybe we just leave it and trust the sail cut will save the day.

Also, if you have taken the batten out of the sail you will have realised just how soft and bendy it is. The batten softness makes it compatible with the way Jeckells made the sail in the luff area. However, this batten is just as bendy in the mid chord part of the sail as it is in the luff area. So, is the batten going to continue to bend in the mid chord part of the sail as it did in the luff area? The answer is no. Here the sailcloth and the cut of the sail stop the batten from bending too much. The sailcloth limits the bend. The same happens in the leech area of the sail - the sailcloth and the cut of the sail restrict the soft bendy batten from bending too much.

The result, in the ideal situation, with the sail trimmed properly and the wind at the correct strength and angle of attack and all sail adjustments correct for the point of sailing is an aerodynamically correct looking/shaped sail. You may have heard that sailing fast upwind is about finding that 'perfect groove' where everything feels just right and the boat is sailing fast. We need to get in and stay in 'the groove'.

Of course, we don't sail in perfect conditions with our sails always perfectly trimmed. The wind is constantly changing in true wind speed and direction and even more so the relative windspeed is changing in speed and direction, across all parts of our sail. The sail isn't perfect. If it's not brand new, it will sag and crease in places. The bolt rope may have shrunk. We end up with a very narrow 'groove' so most of the time we will be out of it and not be getting the most power out of our sail.

What this discussion is pointing out so far is a total lack of sail shape control and stability with our untapered, soft and bendy, battens. Untapered battens give high lift in the sideways direction (affecting how high you can point) and higher drag. They give relatively poor acceleration in gusts, converting the wind energy into more heeling. If you have problems in keeping the boat stable in gusts, then the battens could be your problem. They distort sail shape by giving too fine an entry for the wind at the luff, moving the draft or designed shape too far aft, and giving a rounded leech especially in stronger winds.

Now let's look at what happens with compression tapered battens. Here the front end or luff end of the batten is soft and bendy. The mid length of the batten is stiffer and the leech end of the batten is very stiff.

If properly tapered, this batten naturally bends with the maximum deflection at say 45% chord. Now we have a batten that naturally bends in a shape like Jeckells designed the sail to. This batten is going

to have a very strong tendency to help the sail maintain the design shape regardless of poor sail trim or wind angle of attack, age of the sail etc. This means that the sail is more compliant to the controls, so the boat will be easier to sail. Tapered battens give you a wider groove so you can find the groove easier and sail faster for longer. You will not see a hooking leech like you see at a lot of Class training days. The boat with properly tapered battens will be overall a faster boat as it is more compliant to changing trim and maladjustment.

As sails age they become less able to hold their designed shape. Old sails will lose you a lot of points in boat speed, so if you race competitively then the only solution is to buy an expensive new sail, probably every year. Of course, this is good for sail makers and suppliers as more frequent obsolescence makes for better business. As a consumer, I would like to keep my hard-earned cash by getting things to last longer. Better battens will force an aerofoil shape into a tired sail, giving you more sail 'longevity', so you don't have to buy a new sail quite so often.

Now let's look at the 'nitty gritty' of tapered battens.

Not a lot is known about the batten characteristics which best suit the Supernova Jeckells sail, until the Contender battens came on the market in Spring 2017 (sold by Birmingham Dinghy Services). This was the first commercial offering of tapered battens for the Supernova. Since obtaining a set of these battens, I have been able to test these out in the 2017 Nationals and in club racing since. I did feel they gave a moderate improvement in boat handling in stronger winds.

Convinced that tapered battens should be the way to go I was keen to develop a set that gave better performance in lighter winds as well as being well within the budget of the average Club sailor (sub £100).

I took delivery of a specially designed set of battens from Dynaflex (France) in July 2017 and set about testing these battens alongside the Contender ones. The Contender battens seemed very stiff and perhaps not ideally suited for inland sailing on flat water, where I do most of my Supernova sailing. The Dynaflex battens are intentionally less stiff in the top 3 battens.

Batten 'Stiffness'

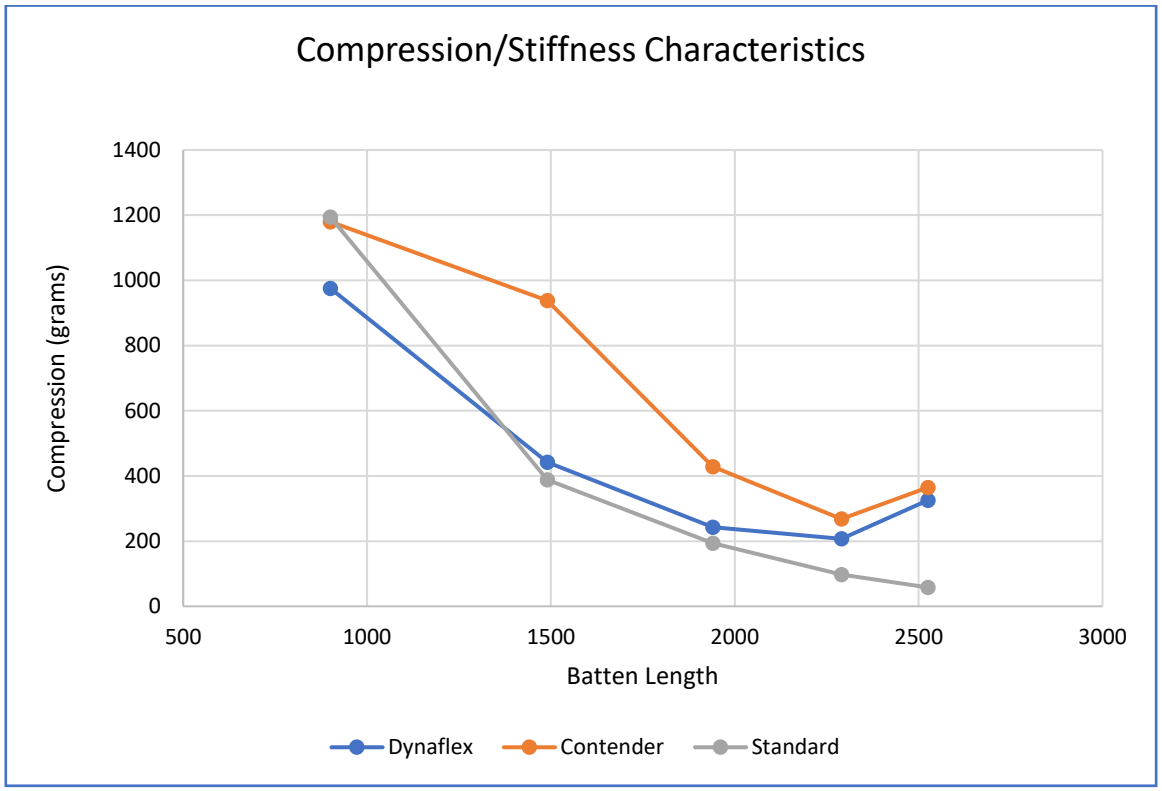
A batten's 'Stiffness' or 'Compression' is the amount of force needed to bend it to a certain degree. To make a comparison between battens, I measured compression when bending to 90% of its straight length.

The stiffer battens will resist dynamic forces better so as a general rule would be used in stronger winds. If too stiff battens are used, these will force a small camber and some power will be lost.

I have measured the stiffness of 3 available types of batten on one sample of each. Note that other samples may vary due to manufacturing variation:

1. Standard untapered 15mm (supplied with the Jeckells sail)
2. Contender Epoxy Glass 15mm (3 battens tapered) – around £160 per set
3. Dynaflex Epoxy Glass 10mm (5 battens tapered) – around £75 per set

The chart below shows the comparison (5 battens on the Jeckells Supernova sail).



You can see that the standard untapered battens are very soft, especially the bottom two longer battens. This makes the leech quite sensitive to oversheeting and applying too much kicker tension. If you don't get it right you will lose power and not be able to point.

In comparison, the both the Dynaflex and the Contender battens are considerably stiffer on the bottom two battens. In theory, this should make the sail more tolerant of mainsheet and kicker and be easier to sail with. It should also be faster in lighter winds as there is less tendency for the air to stall off the sail (making for less drag).

In the middle of the sail the Contender battens are about twice as stiff, with the Dynaflex and standard battens roughly similar. Interestingly the Contender #2 batten (1500mm length) is not tapered which may be why it seems to have excess stiffness (this may be by design although it looks to be too stiff). All the Dynaflex battens are tapered for a 42% maximum draft whereas the Contender battenset has 3 of the 5 tapered. Without tapers, the maximum draft is 50%. In light to moderate winds you want a decent camber in the middle of the sail with the rig fairly tight to generate maximum power. In gusty conditions, the stiffer battens may be a disadvantage as you want the sail to twist off readily in gusts to stop the boat heeling too much and have more control of the boat (at the expense of some power loss).

The Jeckells Supernova sail has a rounded roach, so you don't need an excessively stiff top batten. The sail top section is cut flat so that the draft is decided solely by sailcloth shaping, luff rounding and the

batten profile. Contender UK maintain that the sail already has the draft too far forward in the top section, so the top 2 battens are left untapered. The Dynaflex approach maintains that the draft needs to be maintained at 42% forward and so is profiled. The argument is that draft forward gives better boat control downwind, and a better sail profile in almost all wind conditions (except perhaps in heavy weather where a stiffer batten is needed). I plan to experiment with different options over a few months in a wide variety of wind conditions.

On the Dynaflex top batten the backend is stiffer than the standard batten so should provide a nicer exit angle by increasing windspeed. This is especially important in lighter winds as most of the sail power is generated by the top part of the sail (wind is stronger higher up).

Extra stiffness can be achieved by combining the battens – for example if you use both Dynaflex and standard untapered battens in the same pocket as a pair, the compression pressures are additive so you would achieve roughly the same stiffness as the Contender battens. There would only be a slight increase on the maximum draft position as the standard battens are quite soft, but with a disadvantage of a doubling of batten weight (see below). This would be necessary only on all except the top batten and would be a good solution for heavier airs where there is plenty of wind power to compensate for the heavier sail, but give a more stable rig in gusts. Personally, I would cut the end caps off the standard battens and tape them to the Dynaflex ones to make attachment at the ends easier. You can of course experiment with different batten lengths taped to the leech end of the tapered batten to modify the stiffness without affecting the front-end taper.

Batten Weight

The other characteristic which is quite important is batten weight, especially on a light displacement single-handed boat like the Supernova. Ideally you want a tapered battenset that doesn't add too much additional weight to the sail. The Mylar laminate sail used on the Supernova is reasonably light. Glass epoxy battens are relatively heavy so the Dynaflex battens are 10mm width to save weight without affecting the compression characteristic too much. They are also very durable. You can get carbon fibre and foam-cored battens which are technologically superior but do cost a lot more.

The measured battenset weights (1 sample of each) are:

1. Standard untapered battens (5x 15mm width): 665 grams
2. Contender 3/5 tapered (4x 15/1x 10mm width): 855 grams
3. Dynaflex 5/5 tapered (10mm width): 658 grams

The Dynaflex battens offer similar weight to the standard untapered battens. The Contender battens are about 30% heavier.

Conclusions

I hope that by reading this you now have a better appreciation of what battens do and the importance of their effect on sail shape.

Although more testing is required, I am personally convinced that tapered battens offer an improvement to the way the rig behaves which enhances the sailing experience for the average club sailor. For a reasonable cost, one set of tapered battens seems to be a worthwhile investment.