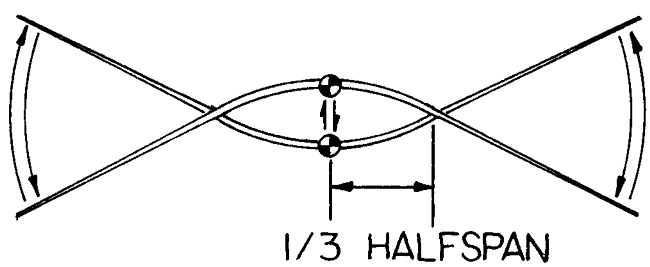
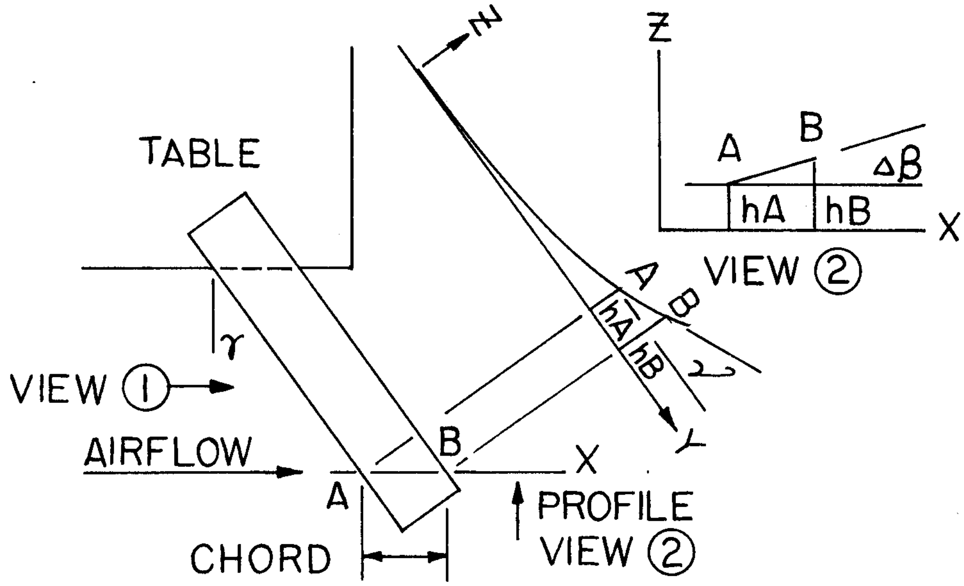
A METHOD OF FLUTTER SUPPRESSION

Swept wing tailless sometimes suffer from flutter at high speed due to a lack of torsional rigidity. The outcome of this flutter is either a reduction in flight speed or destruction of the aircraft.
Dr. Martin Lichte has written an article describing both the flutter and a solution. Published in DELTA #6, the following is a condensation from the German text:

The first drawings show the type of flutter which swept tailless can experience. Notice the front view shows one point on each wing panel which remains motionless, while the side view, which describes the 'wing's path through the air, clearly illustrates the vertical movement of the CG.



Before a remedy can be prescribed we must find the reason for the flutter. Take a piece of sheet balsa and extend 3/4 of it past the edge of a table. "Sweep" the sheet to some angle relative to the table edge, say 20°, and place a flat object, like a book, on the end of the sheet which is resting on the table. If you now lift or depress the free end of the sheet you will see an interesting thing happen; the effective angle of attack of the tip changes, as shown in the next drawing.



There is a twist imparted on the wing by the geometry of the bending. For the technically minded who might be reading this,

$$\Delta\beta = \arctan(\sin\gamma * \tan\nu)$$

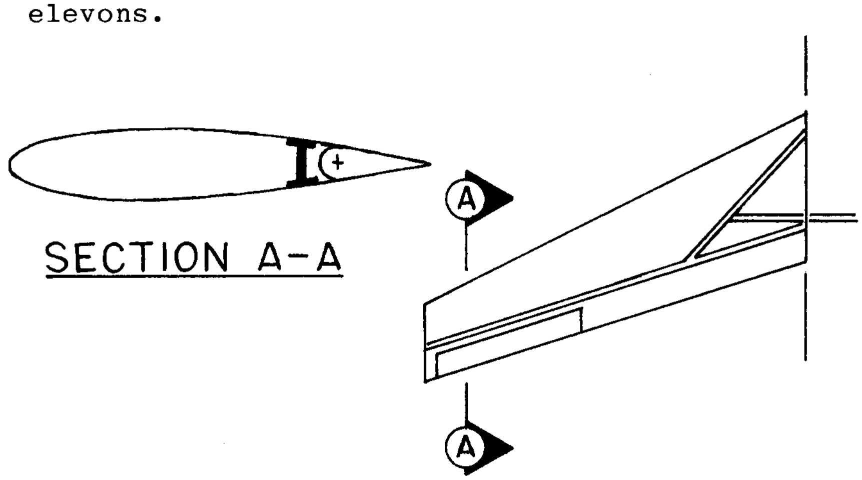
where β = effective angle of attack

This means if you raise the tip 5° when the sweep angle is 20° the resulting change in angle of attack will be 1.7139°. It would appear the increasingly negative angle of attack as the wing is raised would force the wing back down to where it belongs, but this is not what happens. Rather, the wing continues upward until the rigidity of the structure stops the movement. The wing then flexes downward and travels past the point of origin. At some point the end of the wing will again be forced back up by the strength of the structure, and the cycle repeats. This bending of the wing is harmonic in nature and will increase in amplitude as long as the aircraft's speed remains above the flutter threshold, eventually precipitating structural failure. Interestingly, the frequency of the flutter can be changed by changing the mass of the wing - increase the mass and the bending will occur more slowly, decrease the mass and it will speed up.

Tailed airplanes usually don't experience this type of flutter because of the tremendous damping forces exerted by the fuselage and tail assembly. This means one of the most effective ways of dealing with this problem is to simply add a fuselage and tail assembly to the wing - but that would be cheating!

The solution to the problem does not lie in finding a new airfoil for the wingtip, as the basis of the problem does not lie there. An ingenious person may be able to come up with an electronic device to act as a damper, automatically moving the elevons to counteract the otherwise increasing amplitude of the bending and resulting torsion. But instead of taking up time, money, space, and weight with electronic gear it would be better to find a structural solution which could be incorporated during the building of the aircraft structure. Some reduction in flutter can be had by using winglets, for example... but read on!

There is no way all of the bending can be eliminated because there are no perfectly rigid materials, but we can use more rigid materials and place the rigidity where it will do the most good. The drawing below shows the solution presented by Dr. Lichte. The carbon fiber spar is placed well back, near the trailing edge, just in front of the elevons.



When the spar is placed to the rear of the airfoil it counteracts the torsion produced by the bending of the wing and the angle of attack of the tip is much more resistant to change. A fully sheeted foam core wing with this type spar system is very resistant to flutter even without winglets. A retrofit of this spar system would be very difficult in an existing 'wing, but what better reason to build a new one?

Dr. Lichte's article supported an idea presented by Ken Bates in The White Sheet #7 (February/March 1982). Ken's article dealt with some stability problems he was experiencing with his swept wing tailless designs, and he presented the idea of the rearward spar position as a means of controlling the torsion brought about by wing flex. Although Ken didn't talk specifically about this type of flutter, the underlying problem is identical to that presented by Dr. Lichte, and the solution is just as viable. Ken did mention some other alternatives: use (1) lots of taper, (2) thicker airfoils, or (3) lower aspect ratios. But each of these solutions has a negative effect with which you might not want to deal.

DELTA is the magazine of FSV Versmold, a German club which flies only tailless 'craft.

The White Sheet, edited by Sean Walbank, is the magazine of the White Sheet Radio Flying Club, a group heavily involved in slope soaring. Their flying site is a hill overlooking White Sheet Downs, a short distance northeast of Sherborne.