LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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HAM-SAS Spring Box Simulations

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Simulations of the HAM SAS spring box show that the spring box has undesirable low frequency resonances (see table 1 column 2). We make a study to find easy solutions to stiffen the table and mitigate the possible problem.

Table 1

	Simulated frequency		
Mode number (*)	No stiffener	S shape, 5 mm thick stiffener	C shape 8 mm thick Stiffener
7	61.3933	110.987	110.125
8	103.424	135.838	136.613
9	125.822	143.992	143.673
10	129.473	151.123	155.13

(*) note: the first six modes are just the rigid movement of the box, we neglected them.

We noted how some modes, see for example figure1 to 4, have relatively large relative movements between the IP support points of the spring box and the GAS support points of the optical table.

We simulated two kinds of stiffeners intended to reduce this effect After installation of the stiffeners, that relative motion (see figures 6 to13) is strongly reduced. The first mode (110 Hz) is actually a flapping mode of the table corners and the relative amplitude between the IP and GAS is actually only a fraction of the maximum excursion.

The motion of these resonances is mainly vertical. Their quadrupolar nature will null to the first order the transfer of vertical motion to the Optical Bench.

We studied two kinds of stiffeners (figure 5) mounted at the periphery of the spring box, where they can be installed easily, one thicker and one thinner, they have very similar results, see table 1 column 3 and 4.

Thickness of the stiffeners is probably not very important.

The C-shape produces a marginally higher frequency increase (likely because of the thickness) and is easier to implement (bolting from the outside of the spring box). This solution is therefore preferable.

Additional studies adding a stiffener around the box edge are summarized in Table 2 and figures14 to 21.

The stiffener has the shape of an L shaped profile, 10 mm thick, 50 mm tall, bolted to the perimeter of the spring box. Unfortunately, there is not enough room to accommodate a taller stiffener. We run simulation with this stiffener with and without the C-shaped stiffener.

The result is that in both cases (with and without C-stiffener) some frequencies actually decrease because of the added mass (7 and 9) and some increase (8 and 10). There is no advantage in adding this stiffener.

Cross shaped stiffeners between the two spring box plates increased the resonance frequency modes. very marginally

Table 2:

	Simulated frequency			
Mode number (*)	No Stiffener	C-shape Stiffener	Perimeter Stiffener	C-shape + Perimeter Stiffener
7	61.4	110.1	59.9	92.7
8	103.4	136.6	116.4	125.6
9	125.8	143.7	120.6	136.5
10	129.5	155.1	132.2	137.7

Finally we made a study cutting out the external portion of the top plate of the spring box to make the top plate of the same dimensions of the bottom one.

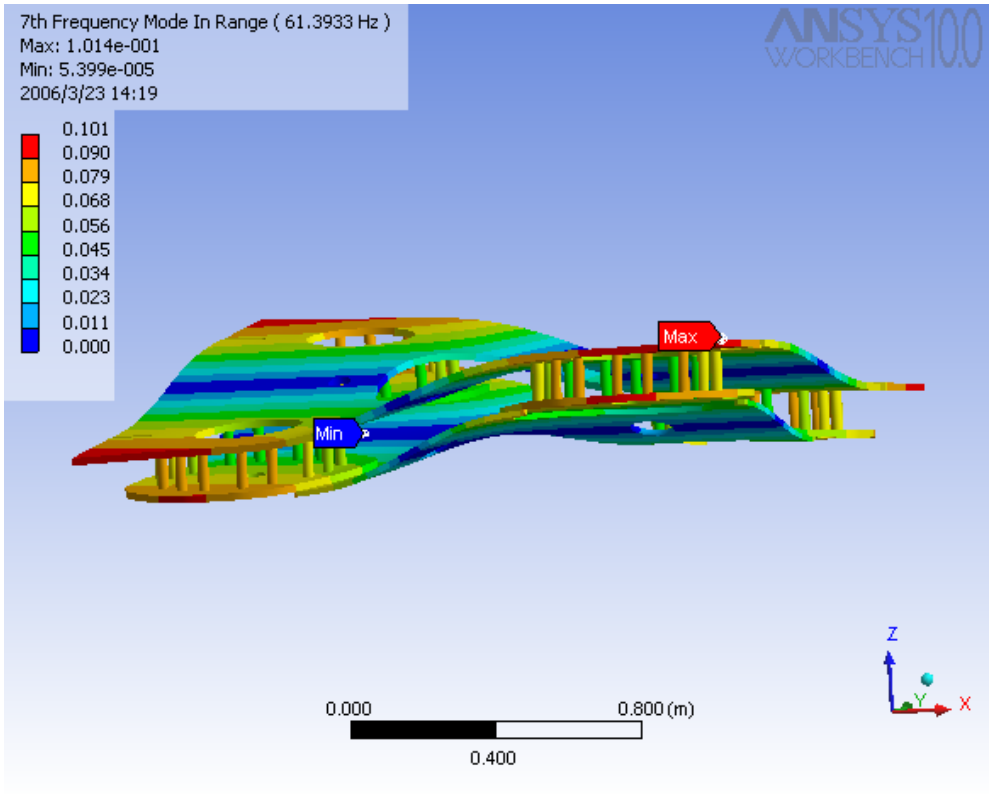
In practice it may not be easily feasible to cut out this portion, because it is used to house the provisional resonant dampers, accelerometers and active tilt/transversal motion damper actuators, as well as being used for transport and positioning.

This modification further increases the resonant frequencies, see table 3, fig 22 to 25.

If tests were to show that all the provisional instruments listed above are unnecessary, then it would be conceivable to make this modification.

Table 3:

	Simulated frequency	
Mode number (*)	C-shape Stiffener	C-shape + Cut perimeter
7	110.1	125.4
8	136.6	143.6
9	143.7	154.5
10	155.1	168.4



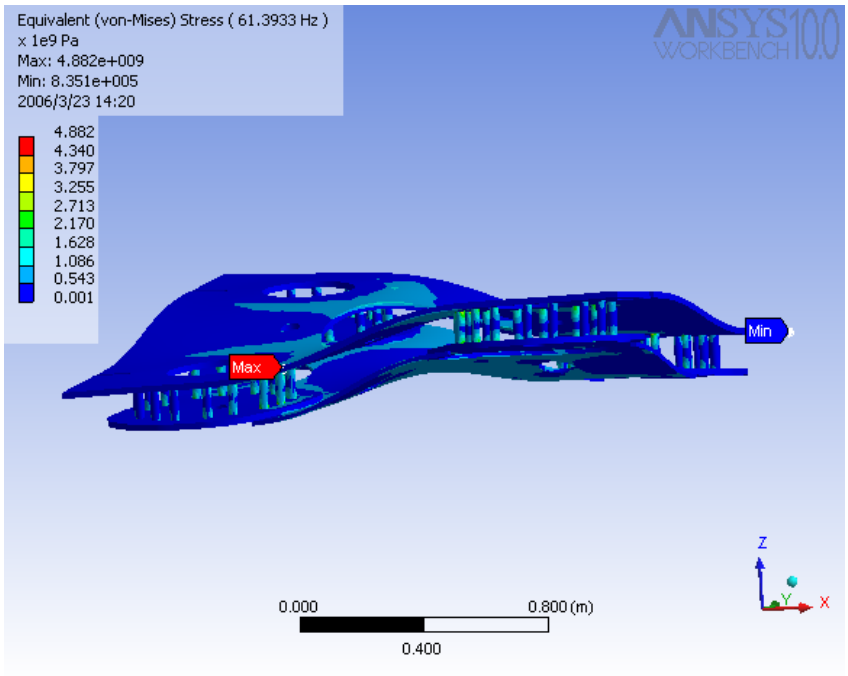
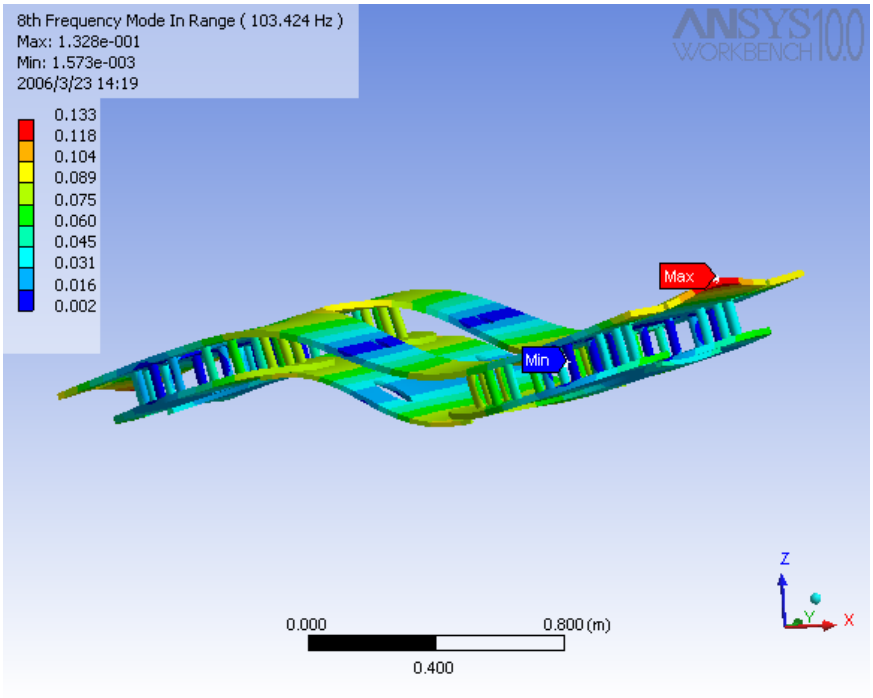


Figure 1 Mode 7 without stiffener.



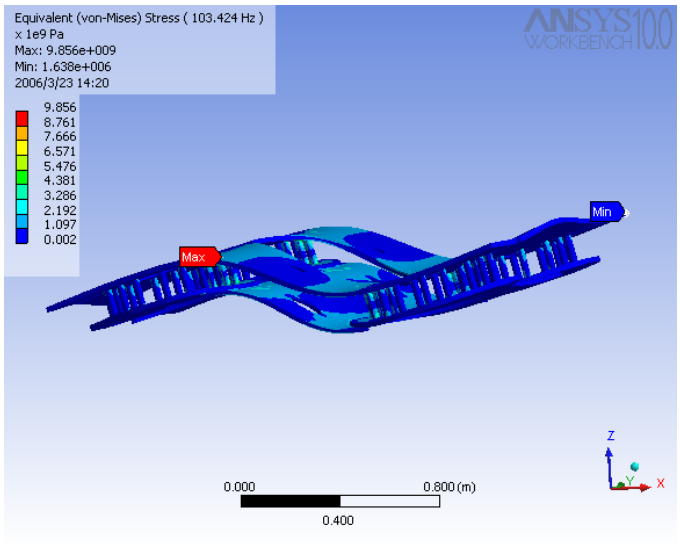
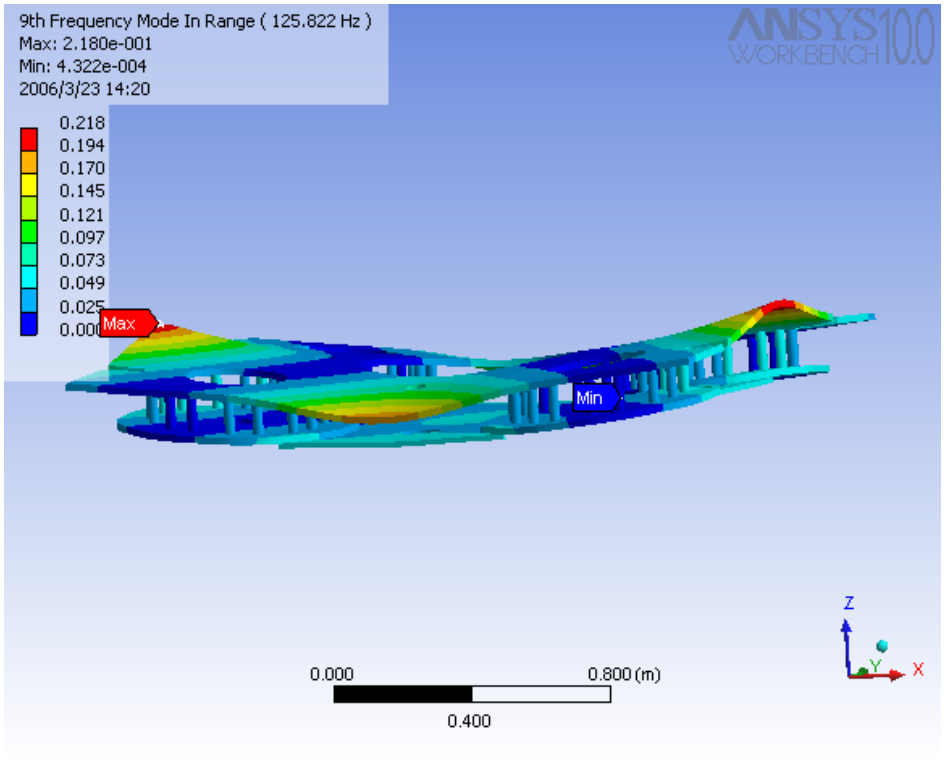


Figure 2, Mode 8, no stiffener



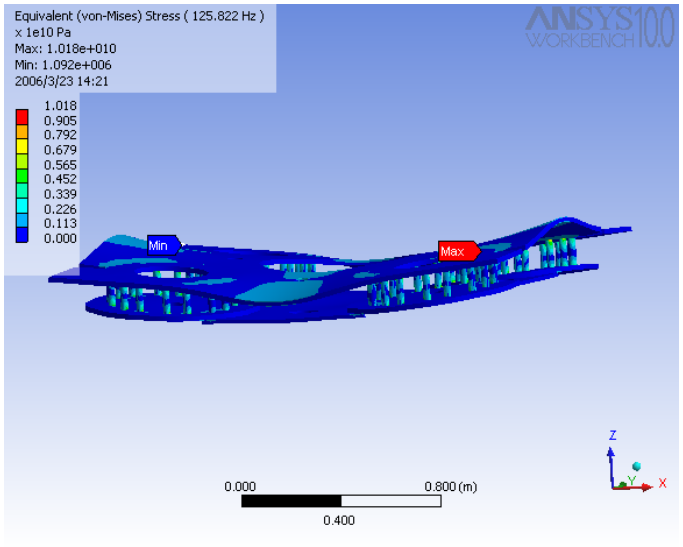


Figure 3, Mode 9, no stiffener

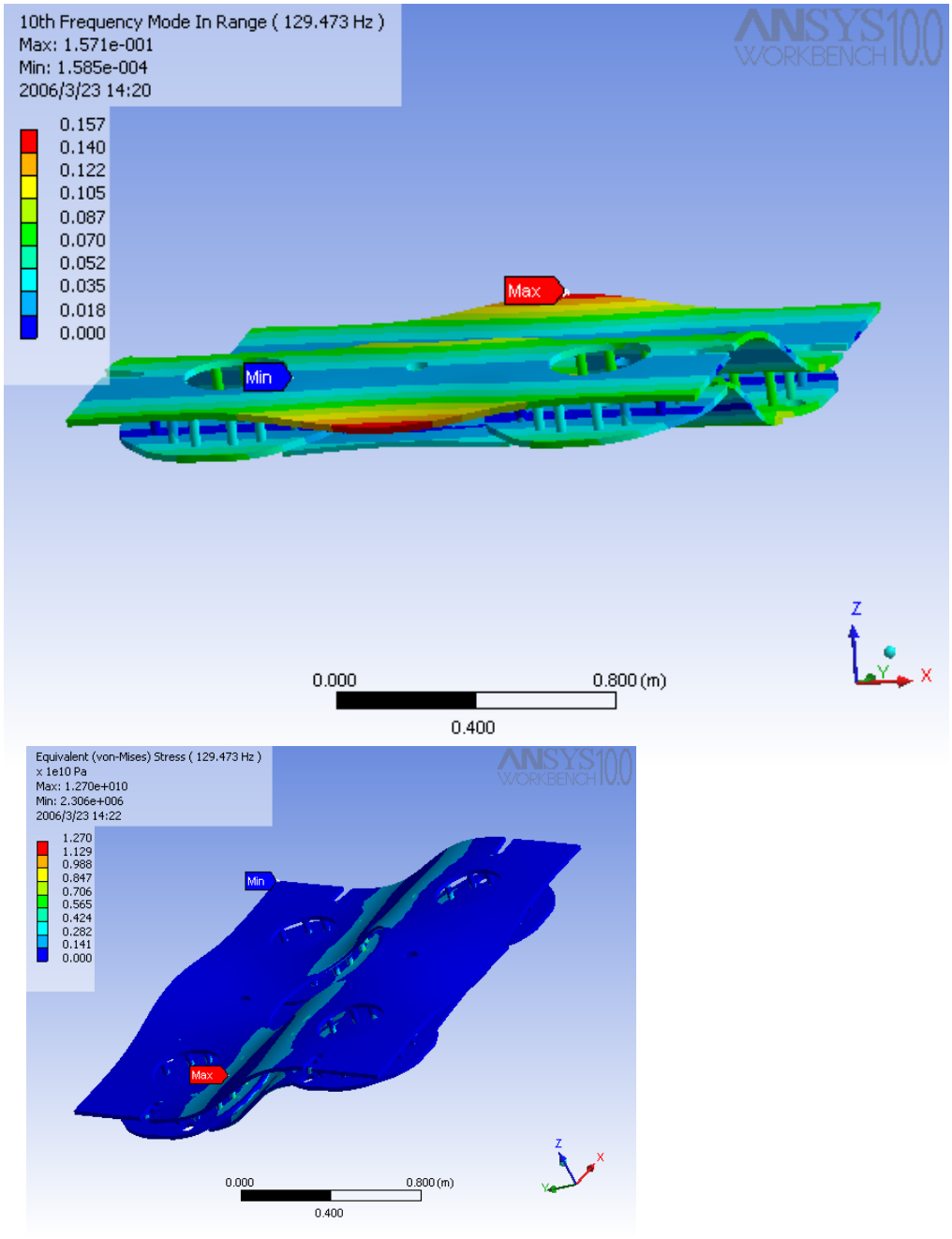


figure 4, mode 10, no stiffener.

2) Then we add the S

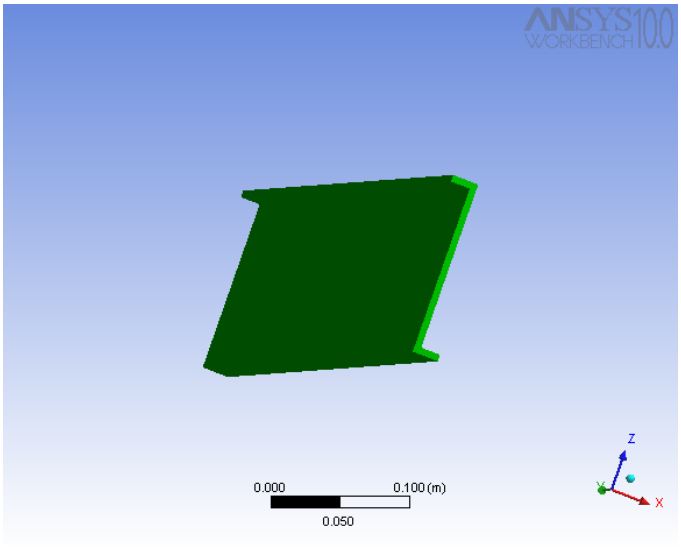


Figure 5-A, S-shaped stiffener

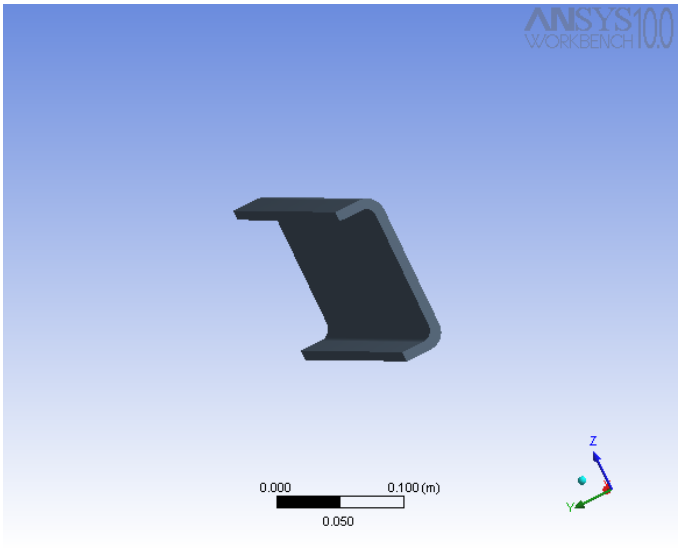
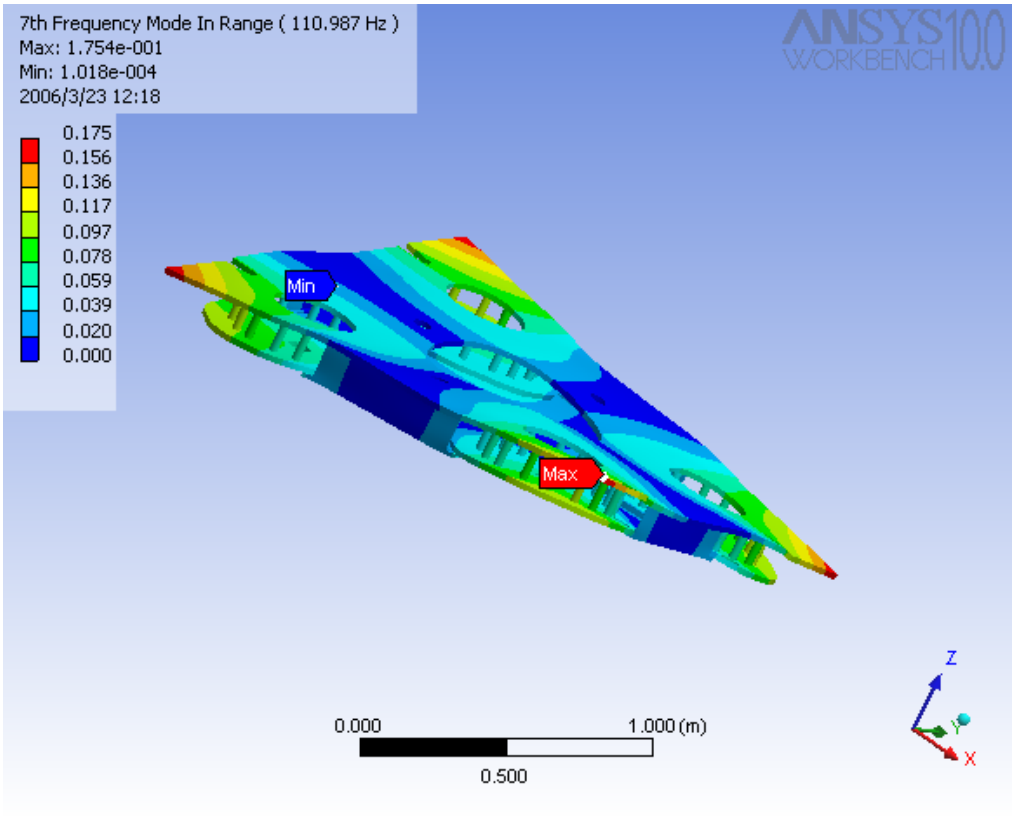
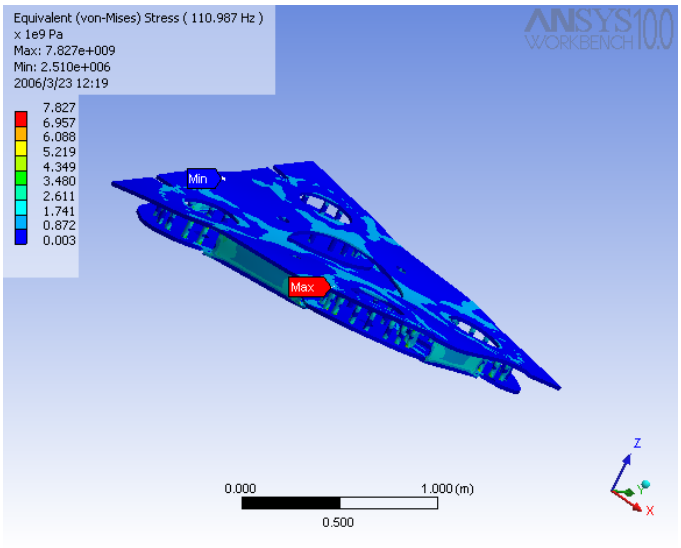
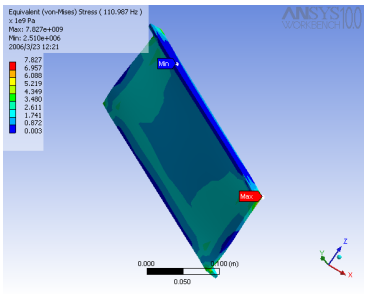


Figure 5-B, C-shaped stiffener







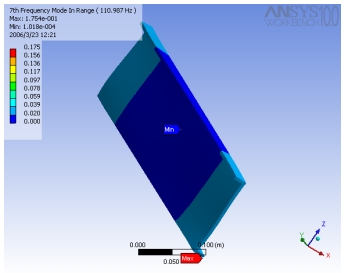
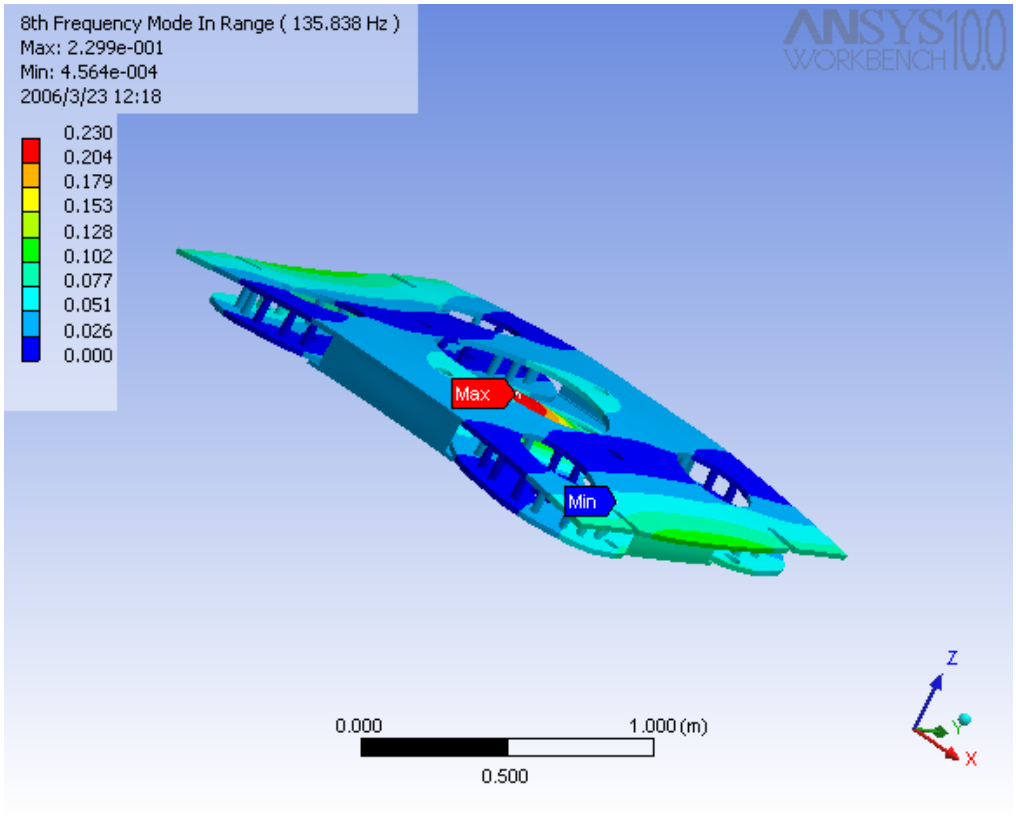


Figure 6, mode 7, S shaped stiffener



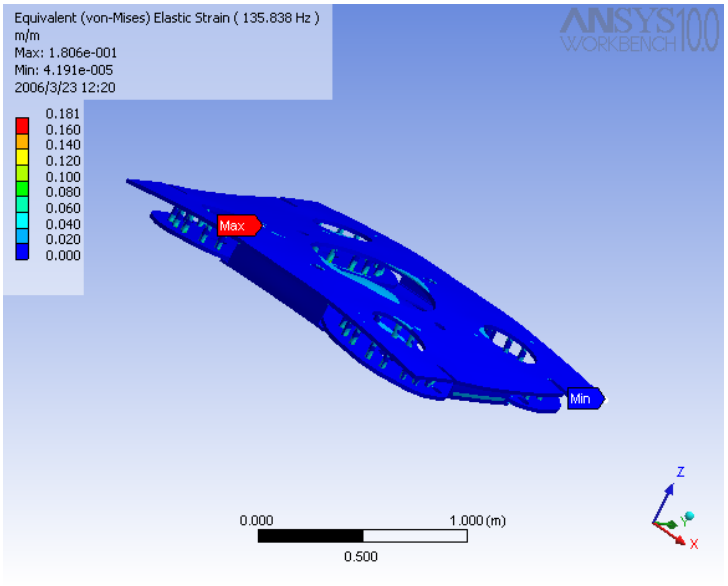
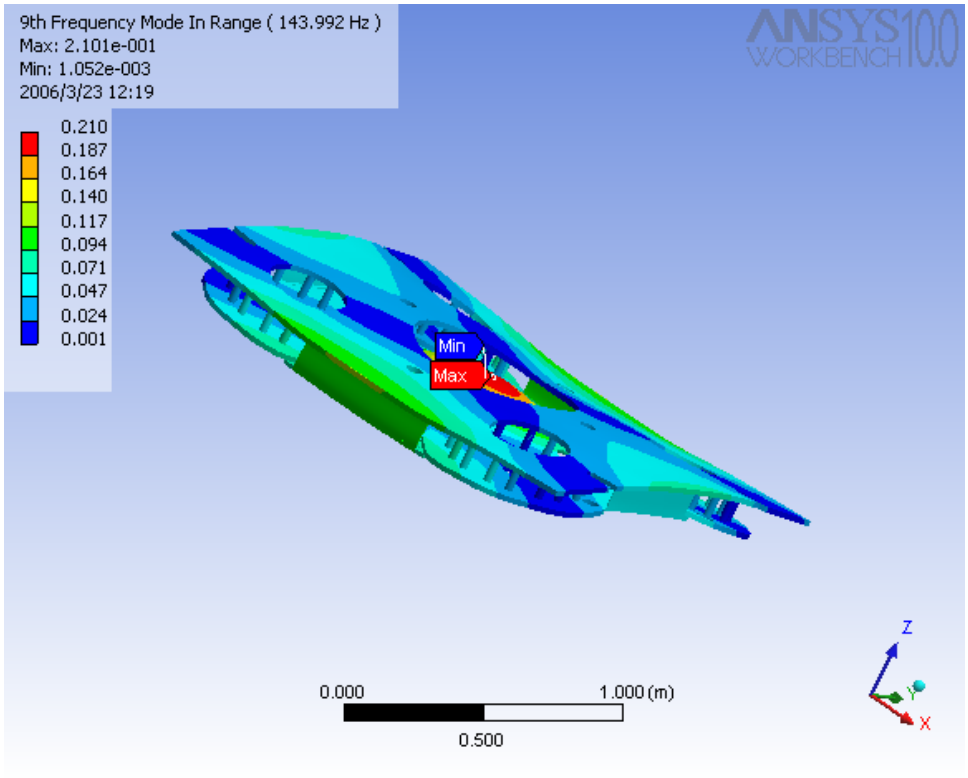


Figure 7, mode 8, S-stiffener.



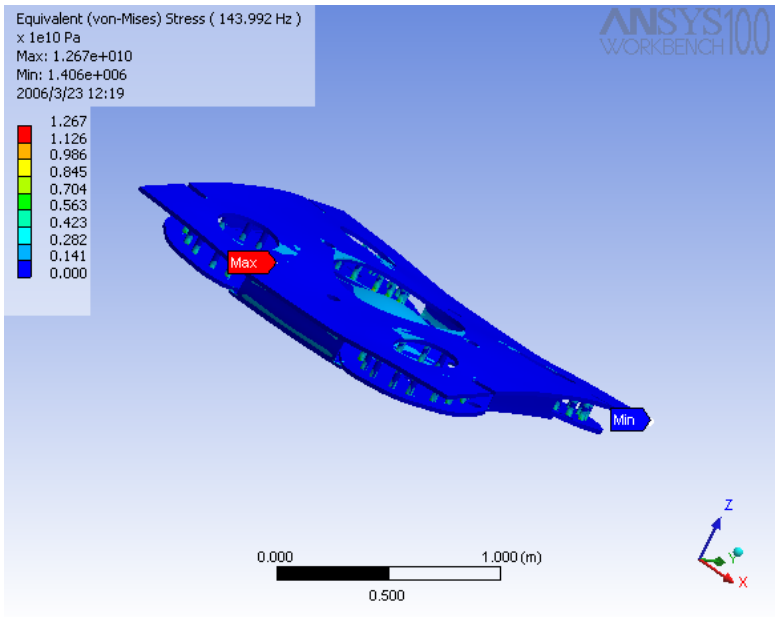
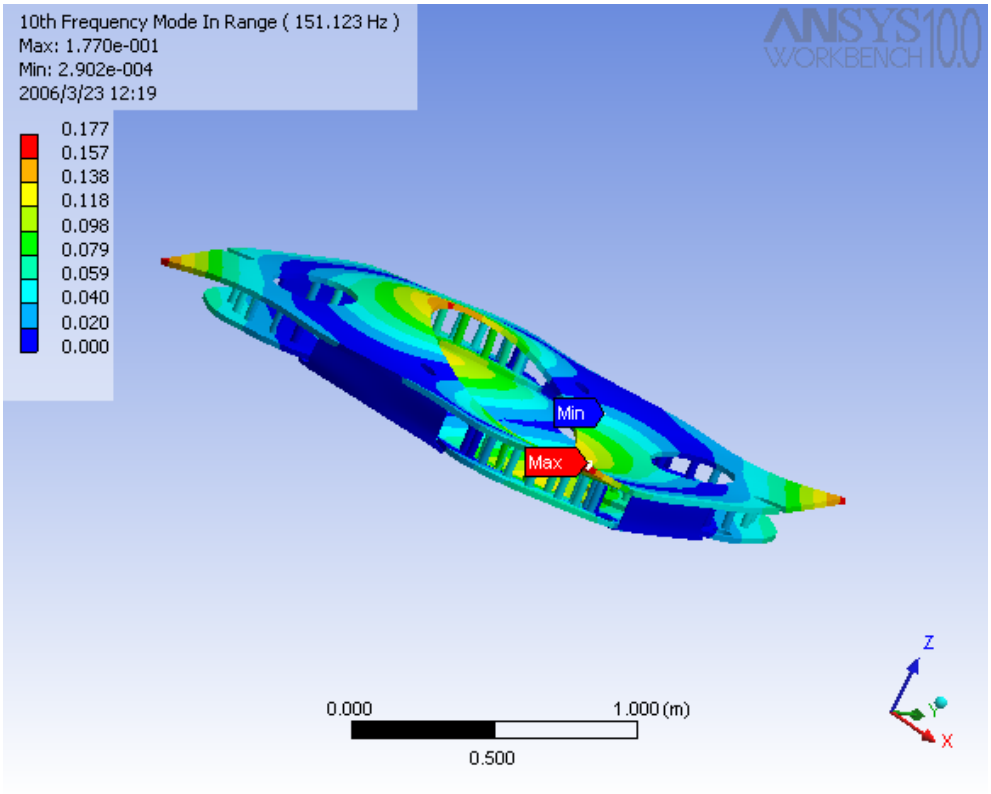


Figure 8, S- shaped stiffener, mode 9



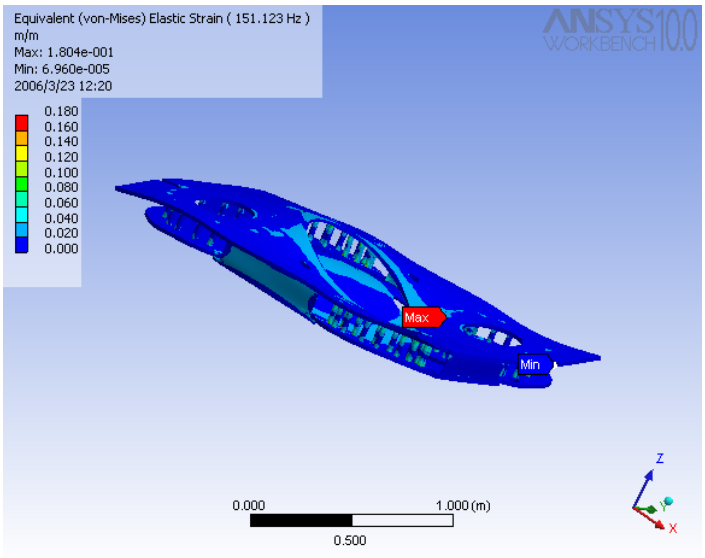


Figure 9, 10th mode S- stiffener

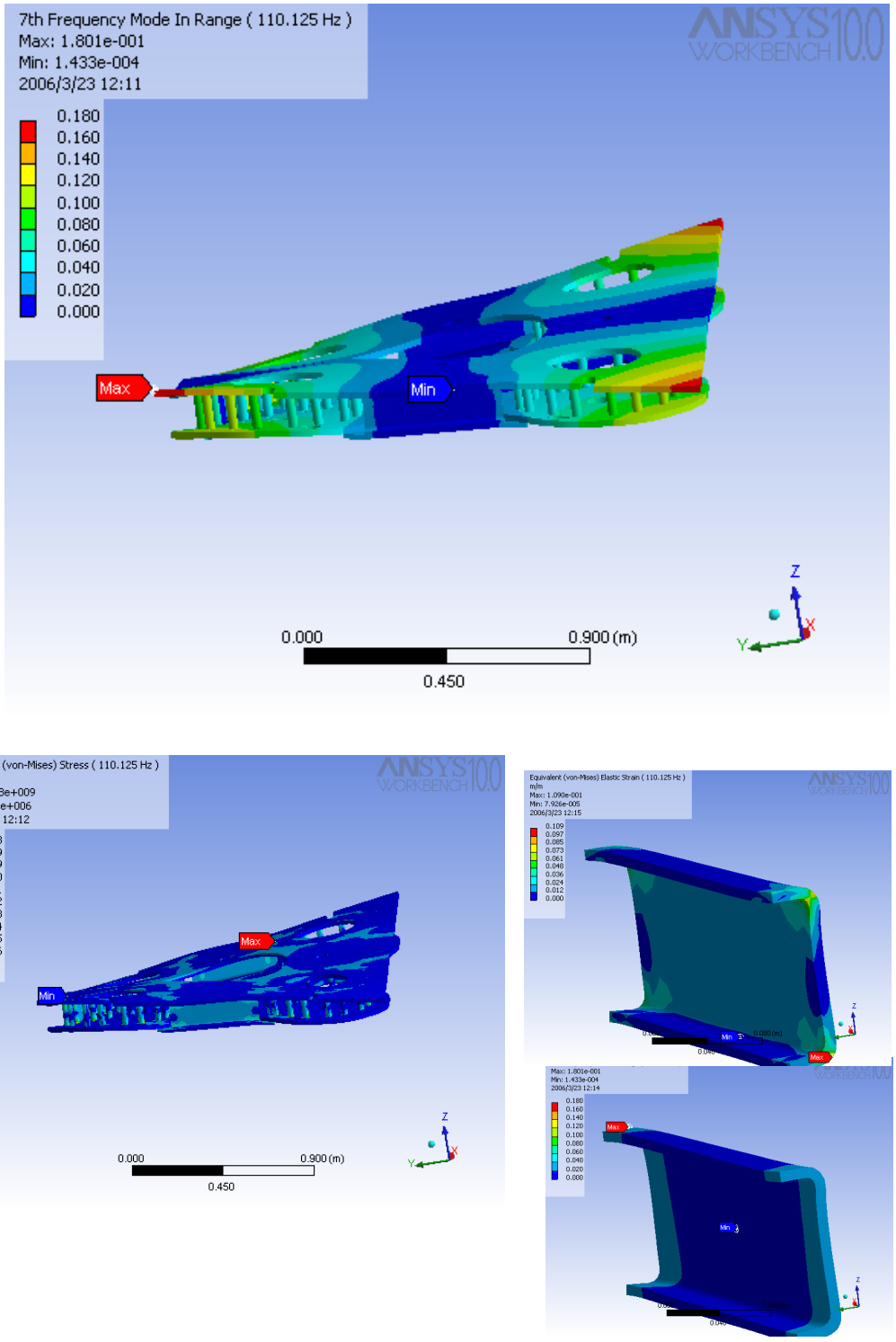
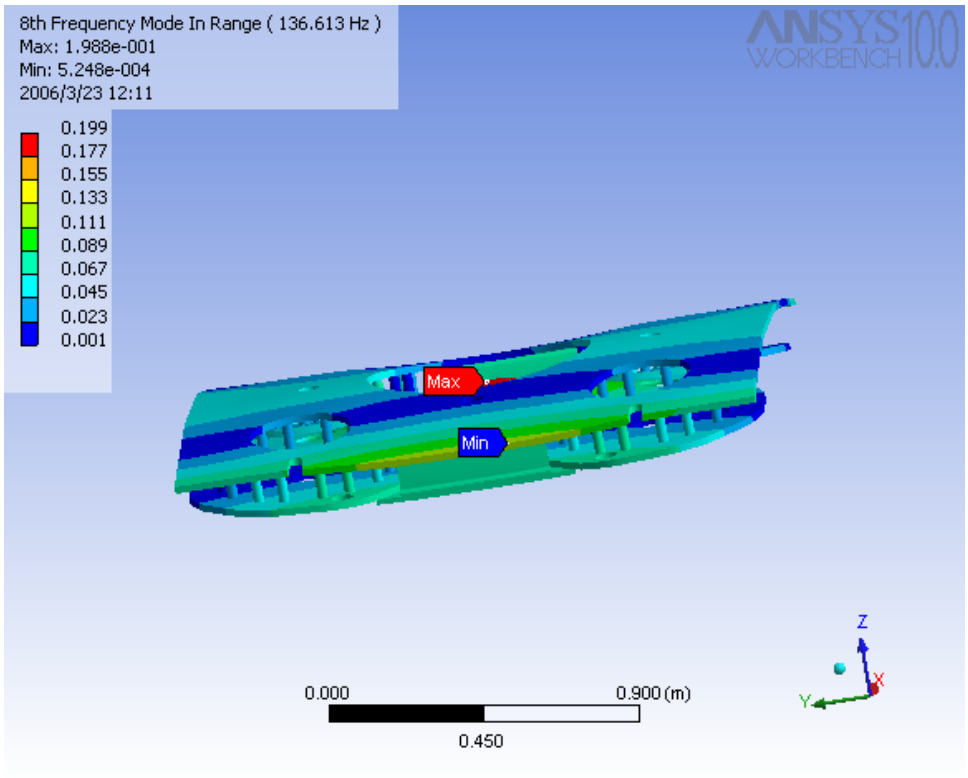


Figure 10, 7th mode C- stiffener



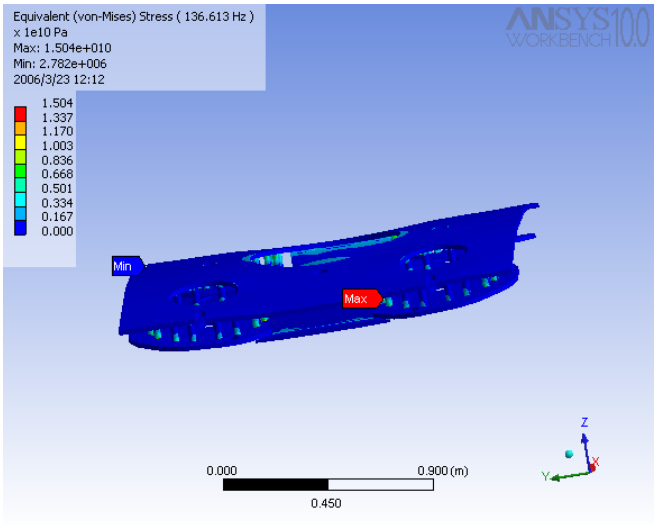
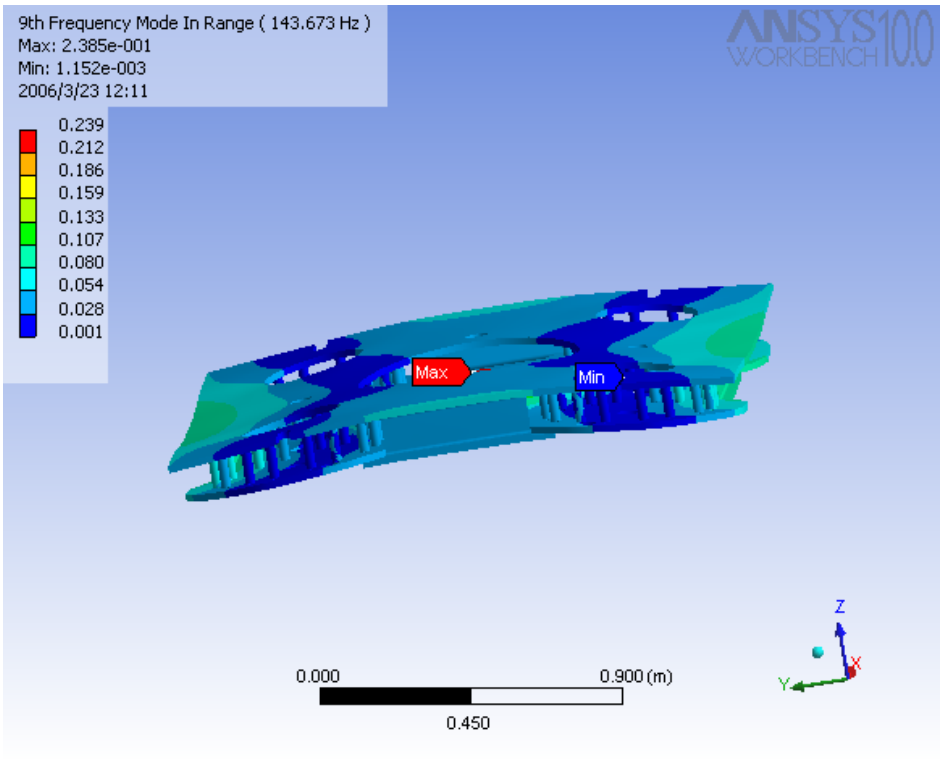


Figure 11, 8th mode C- stiffener



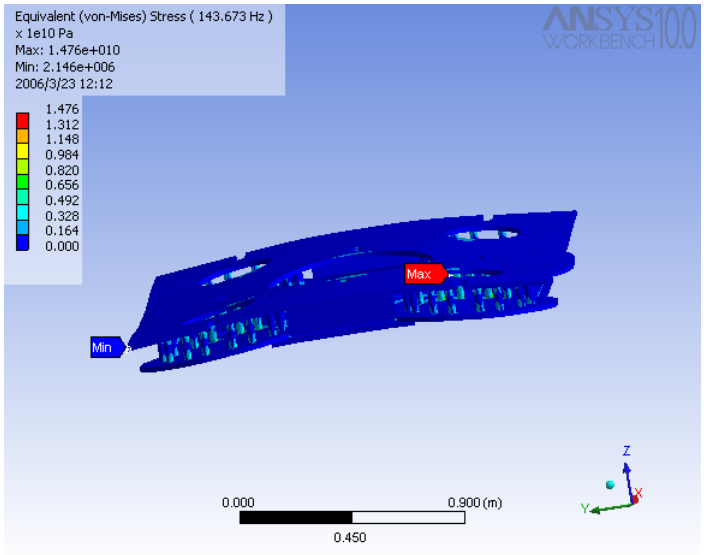
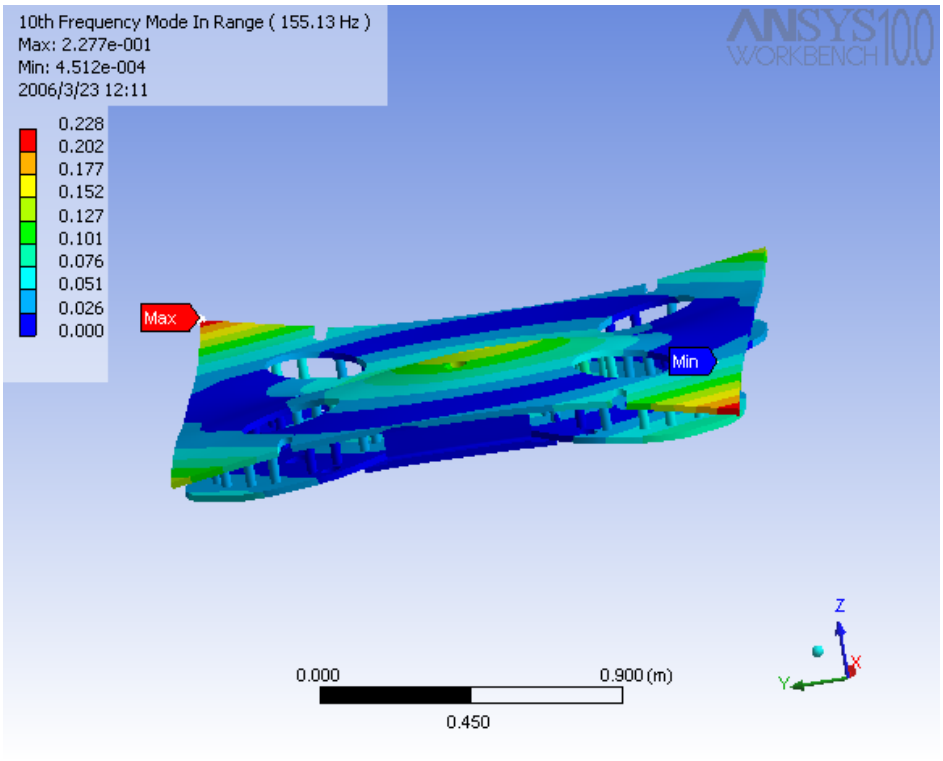


Figure 12, 9th mode C- stiffener



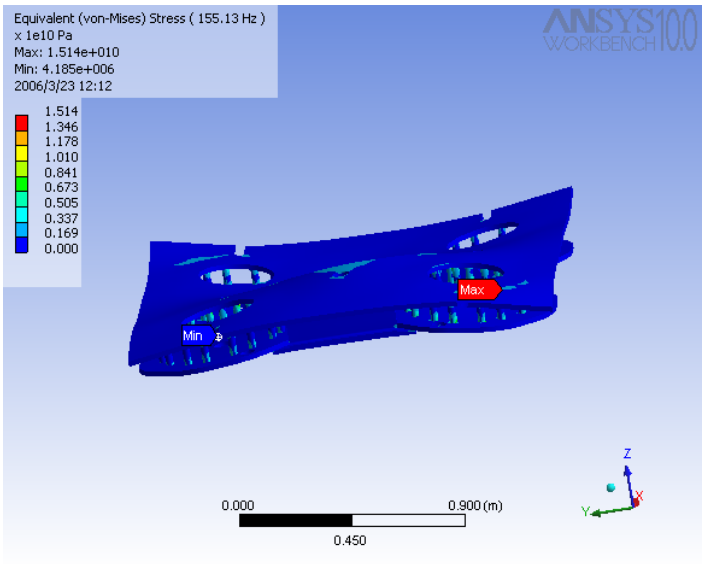
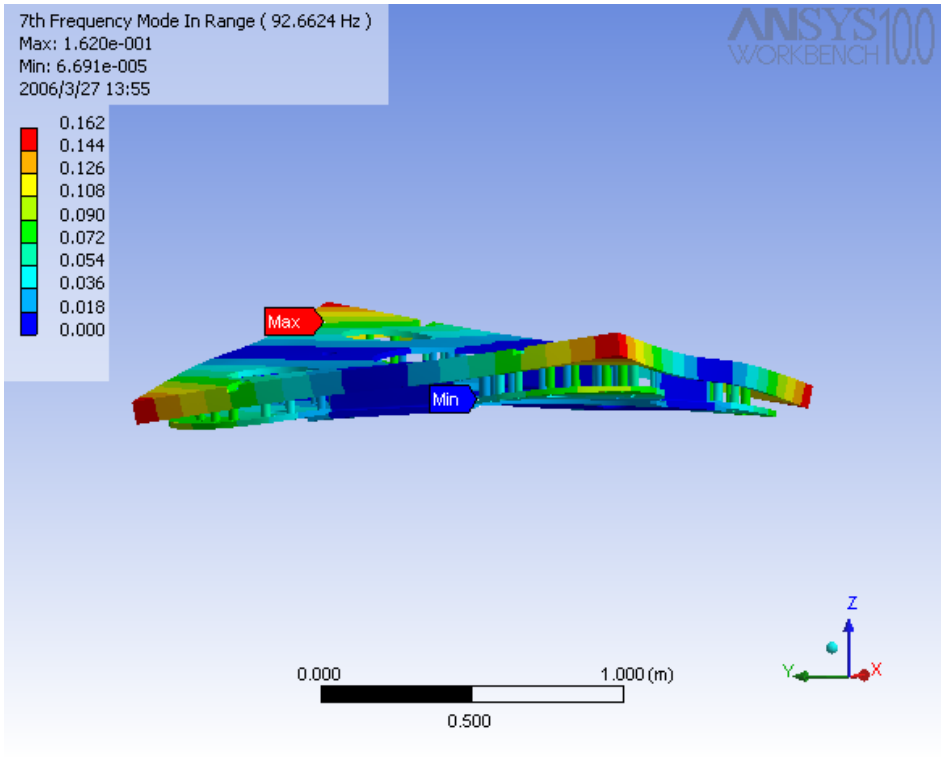


Figure 13, 10th mode C- stiffener



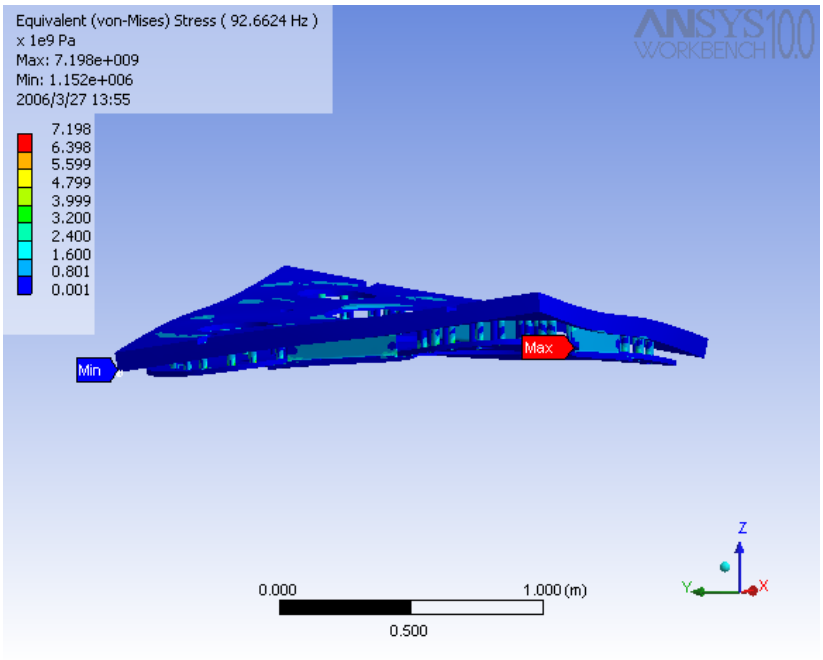
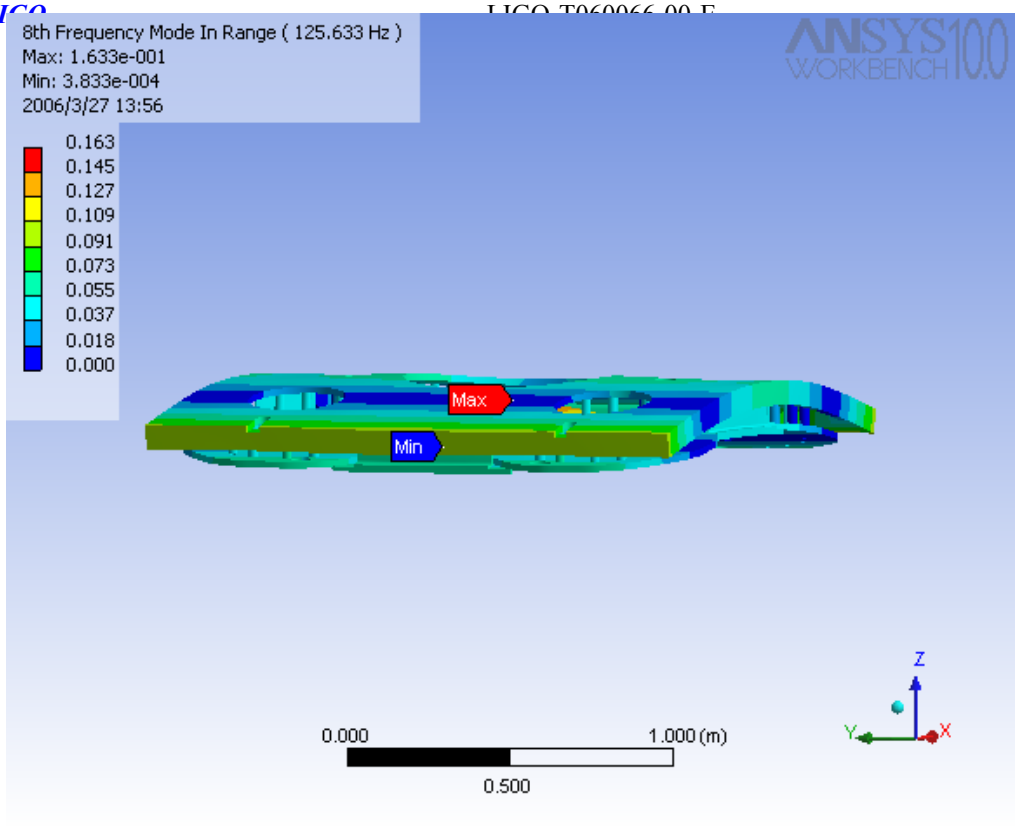


Figure 14, 9th mode C- stiffener + perimetral stiffener



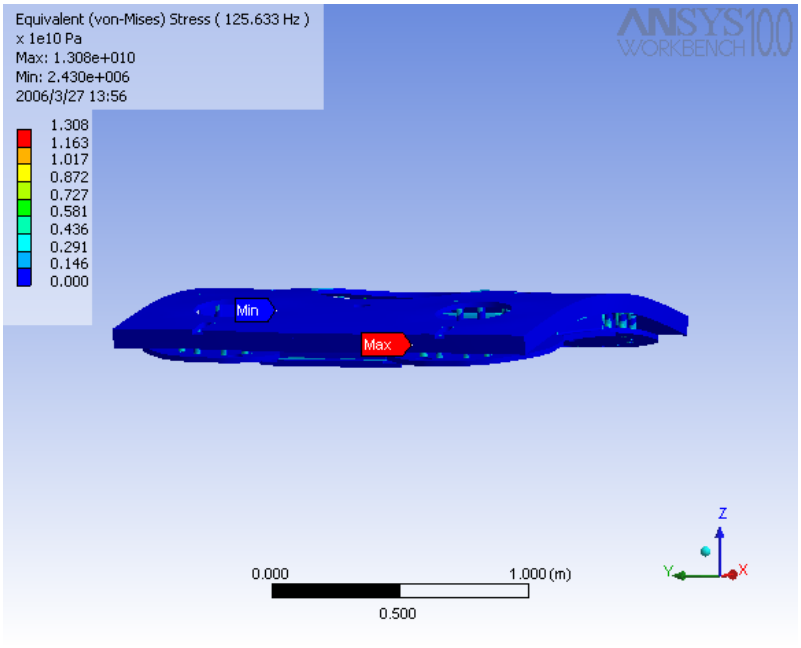


Figure 15, 8th mode C- stiffener + perimetral stiffener

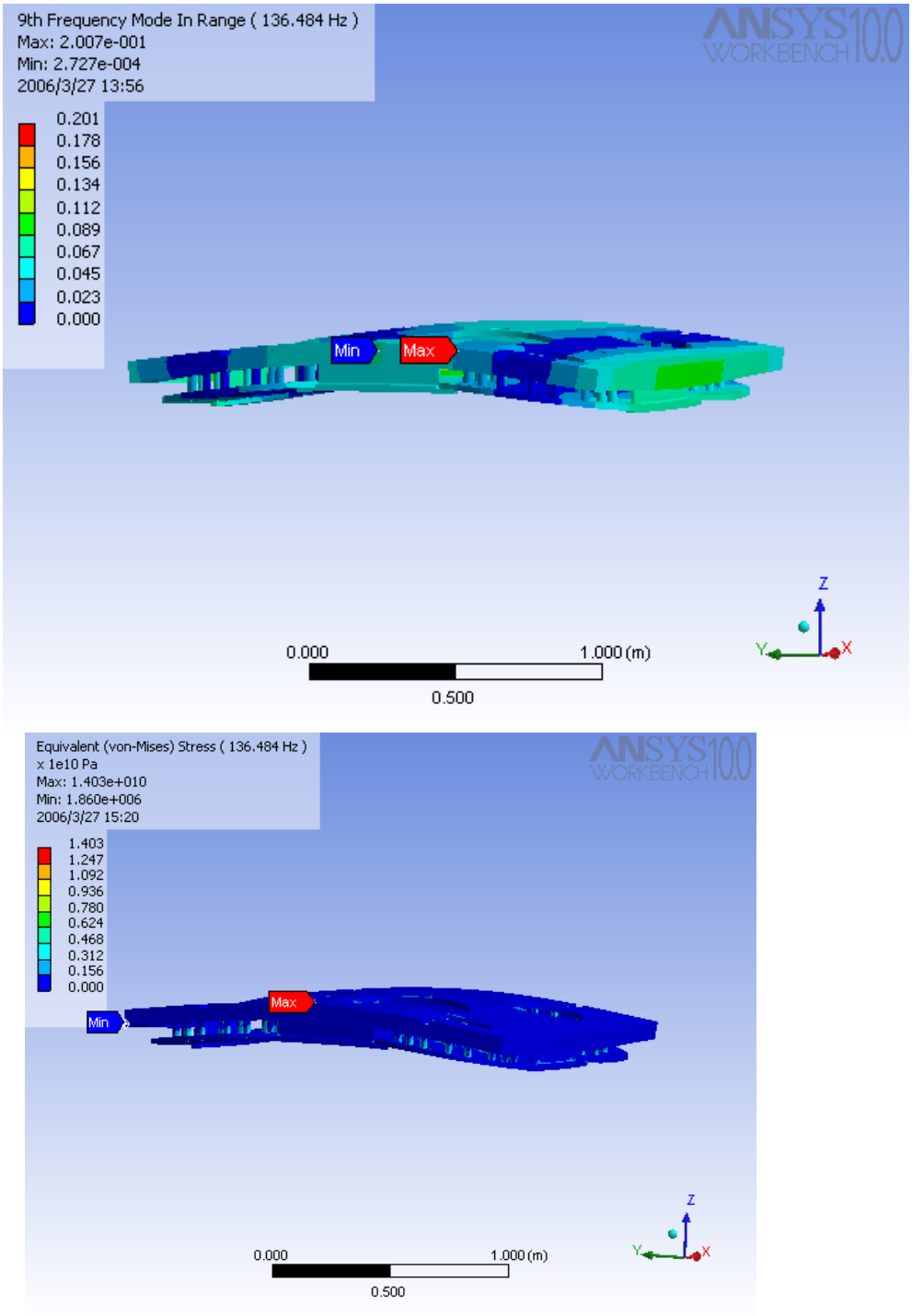
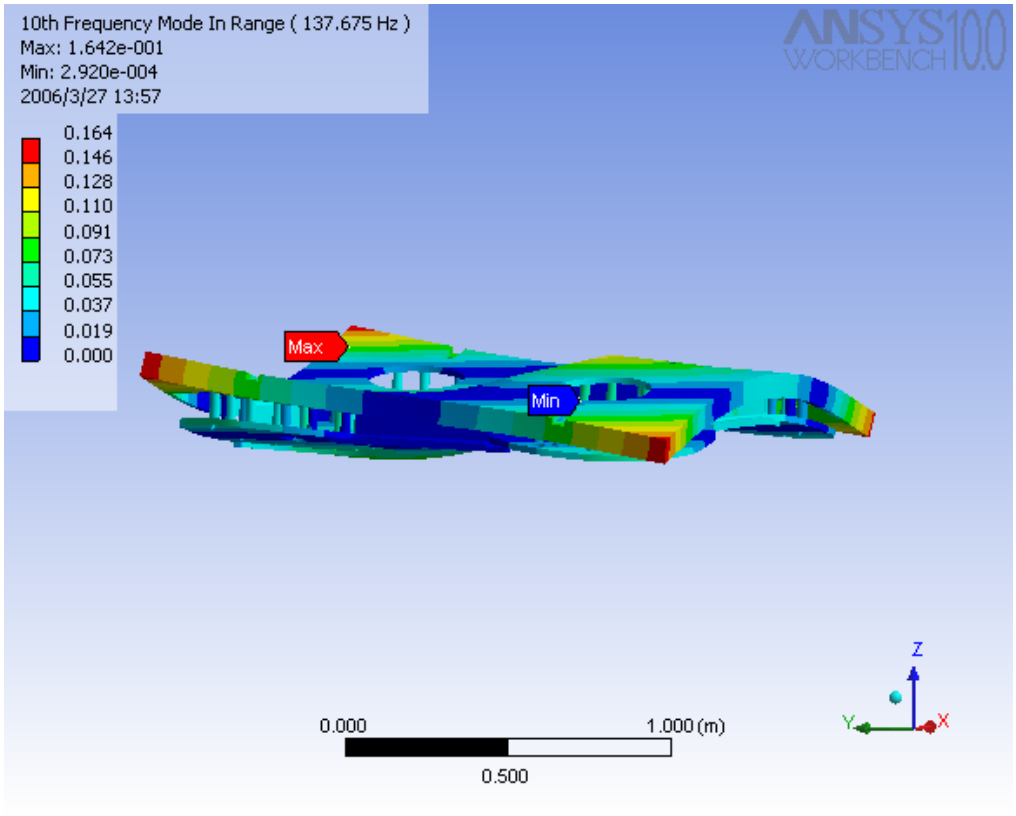


Figure 16, 9th mode C- stiffener + perimetral stiffener



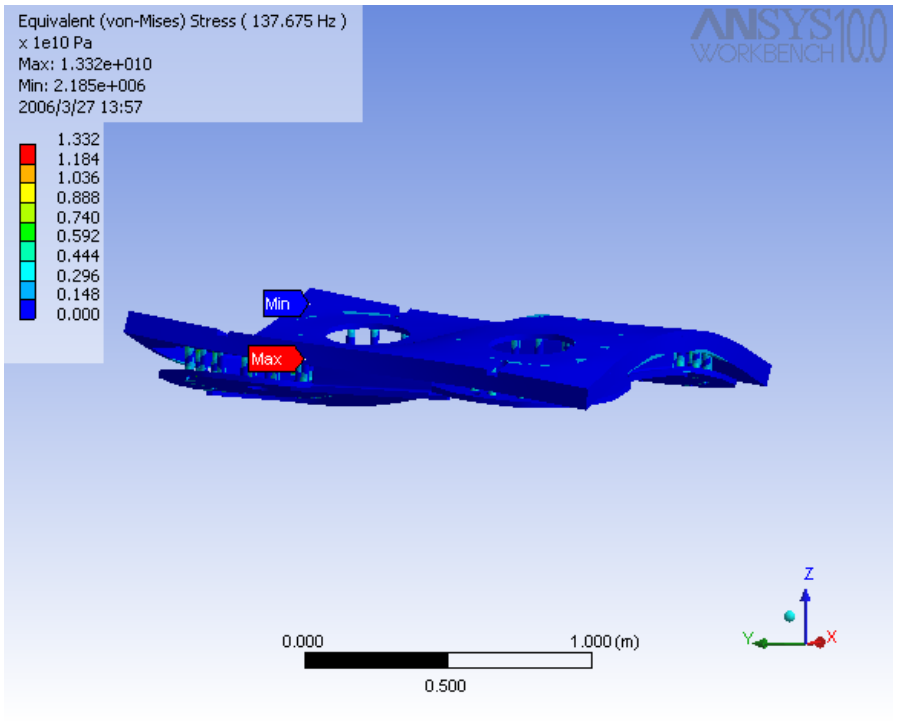
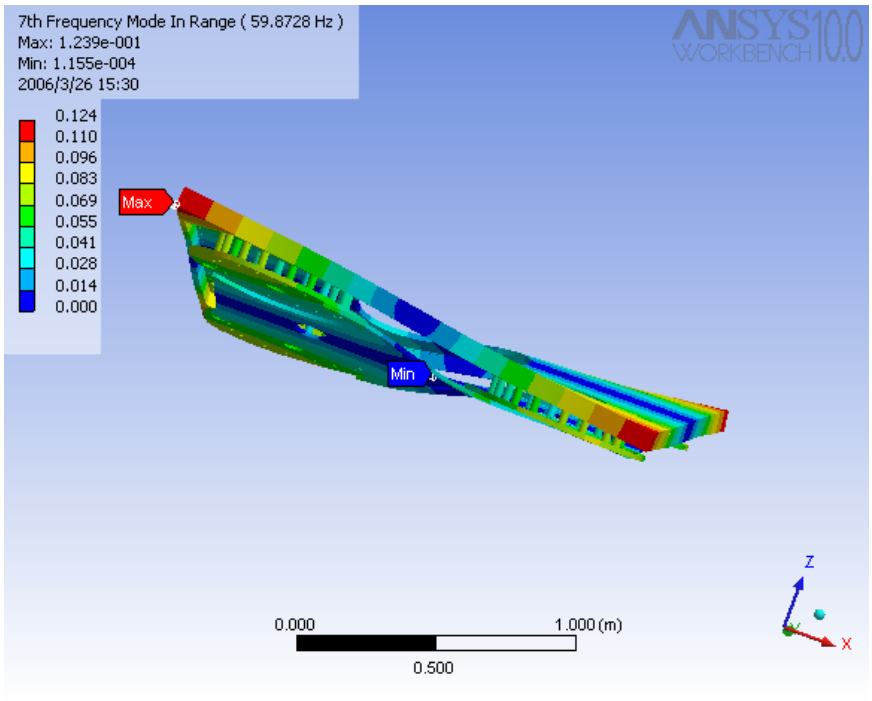


Figure 17, 10th mode C- stiffener + perimetral stiffener



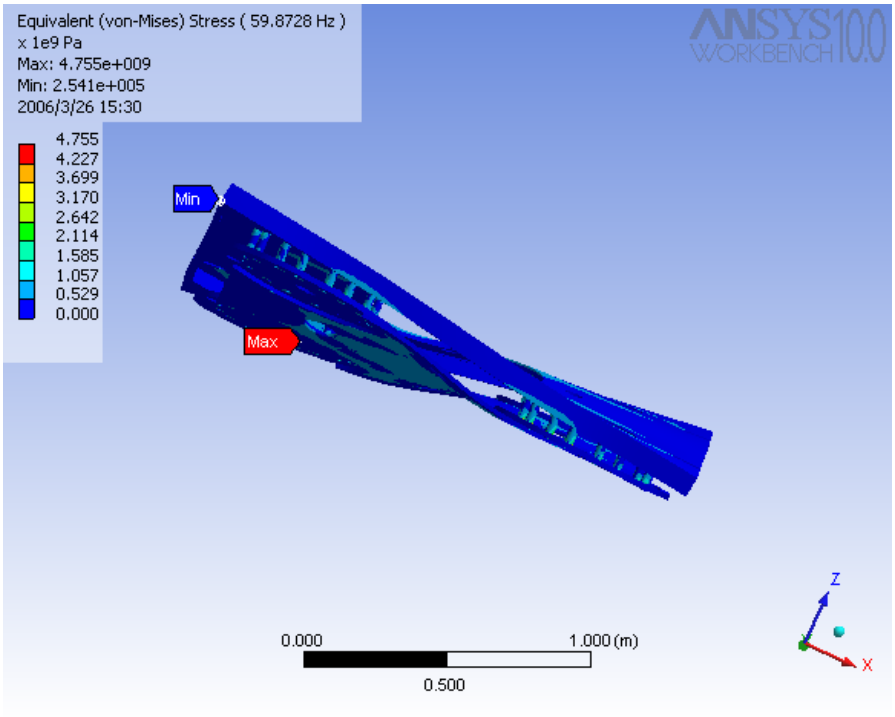
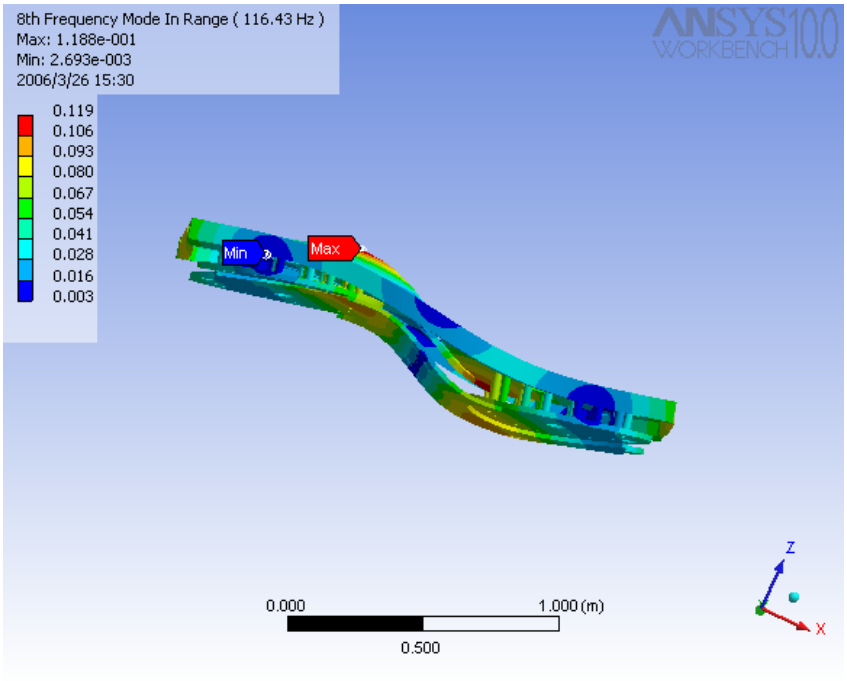


Figure 18, 7th mode perimetral stiffener



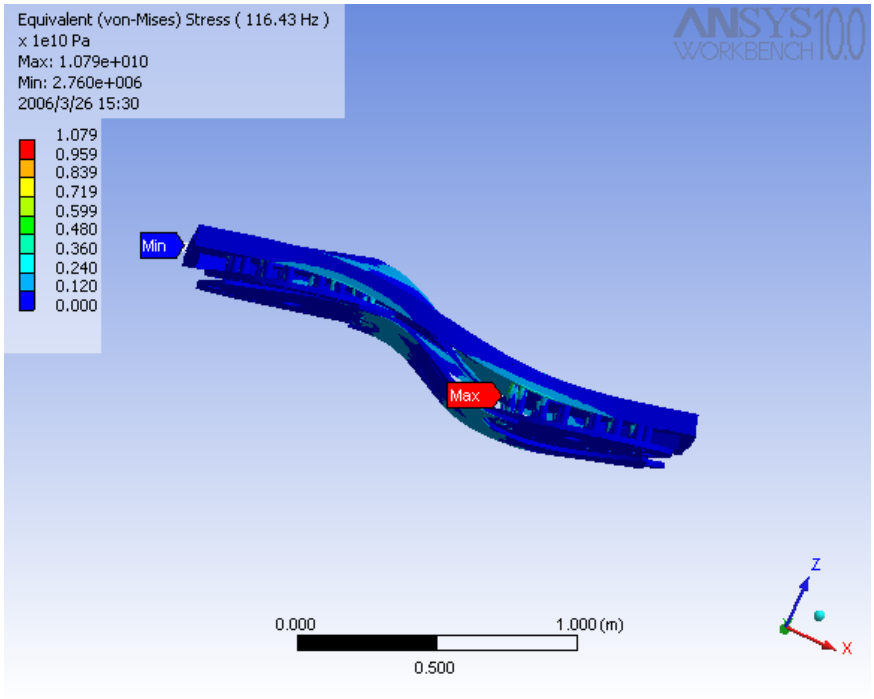


Figure 19, 8th mode perimetral stiffener

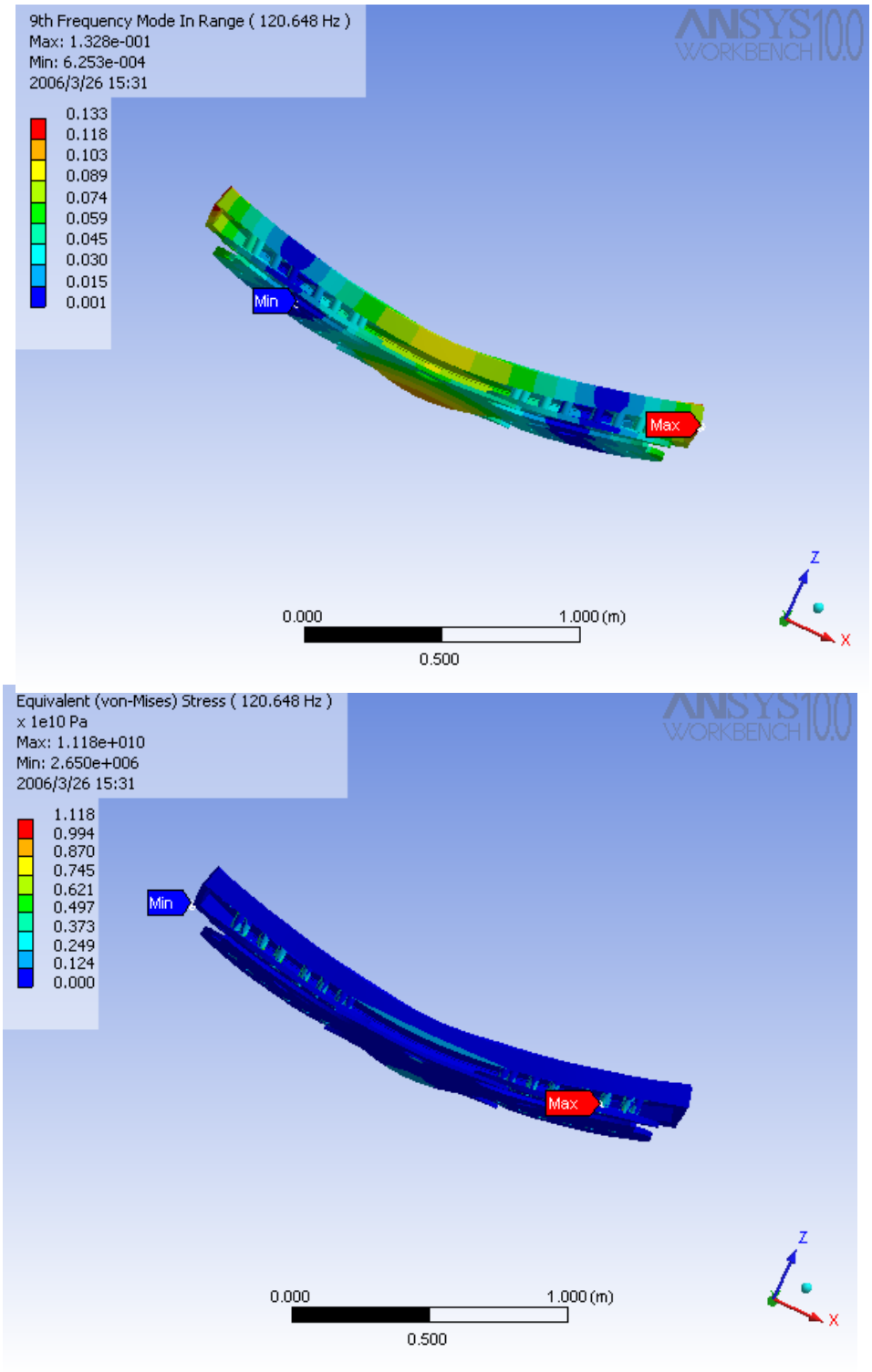
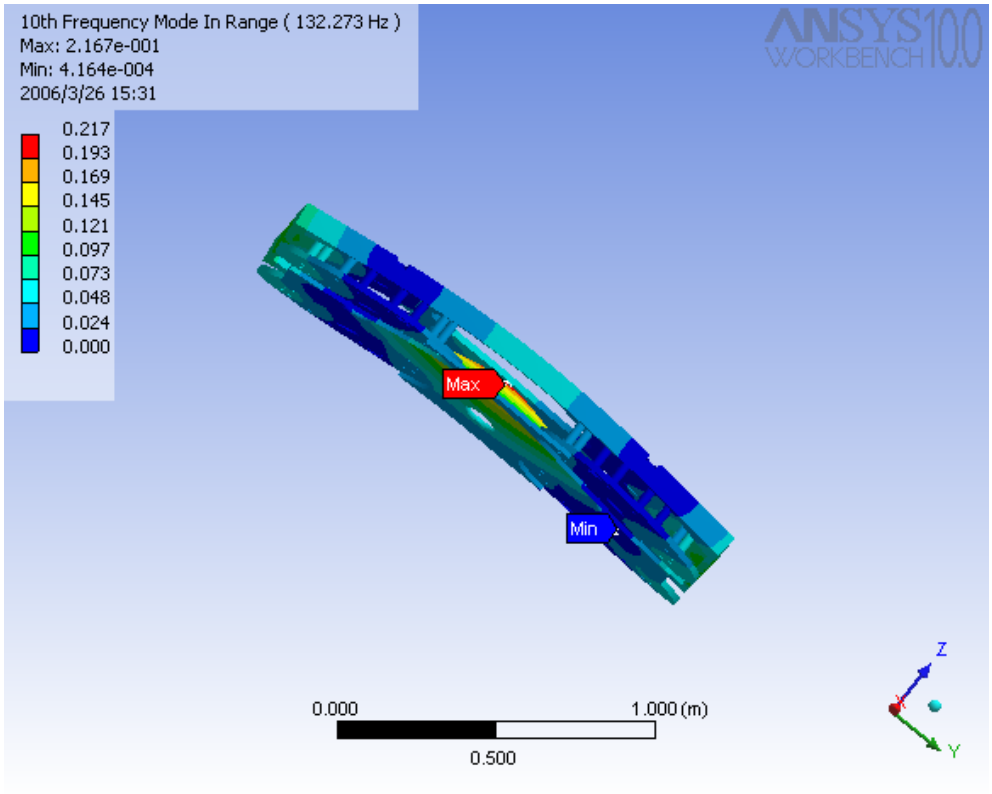


Figure 20, 9th mode perimetral stiffener



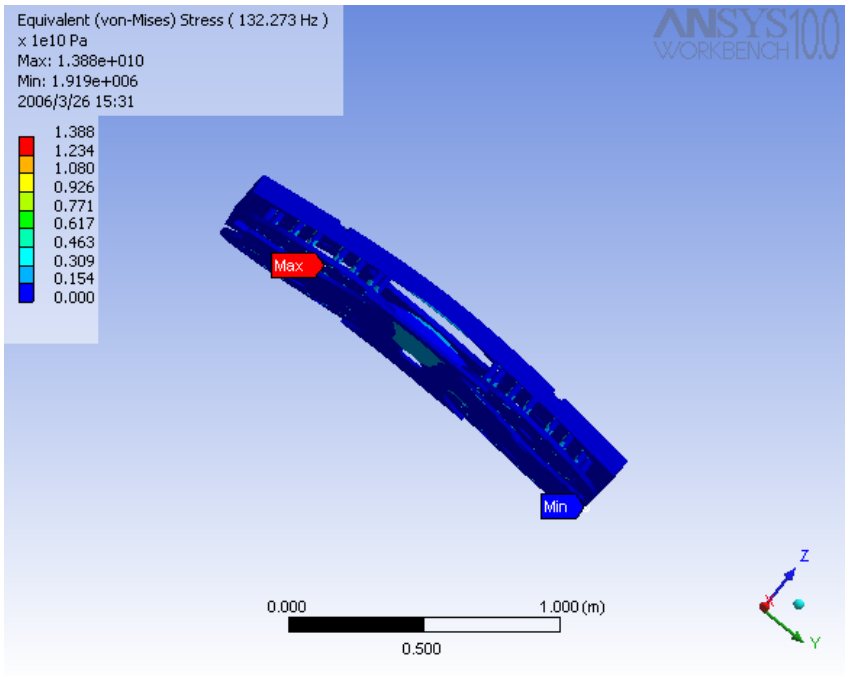
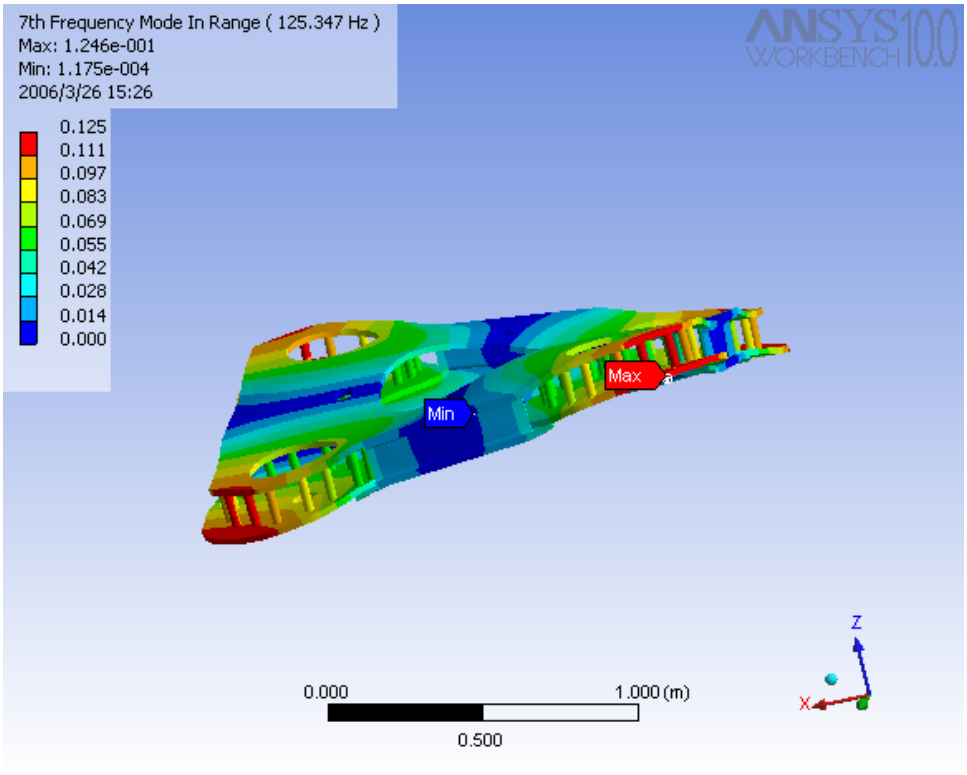


Figure 21, 9th mode perimetral stiffener



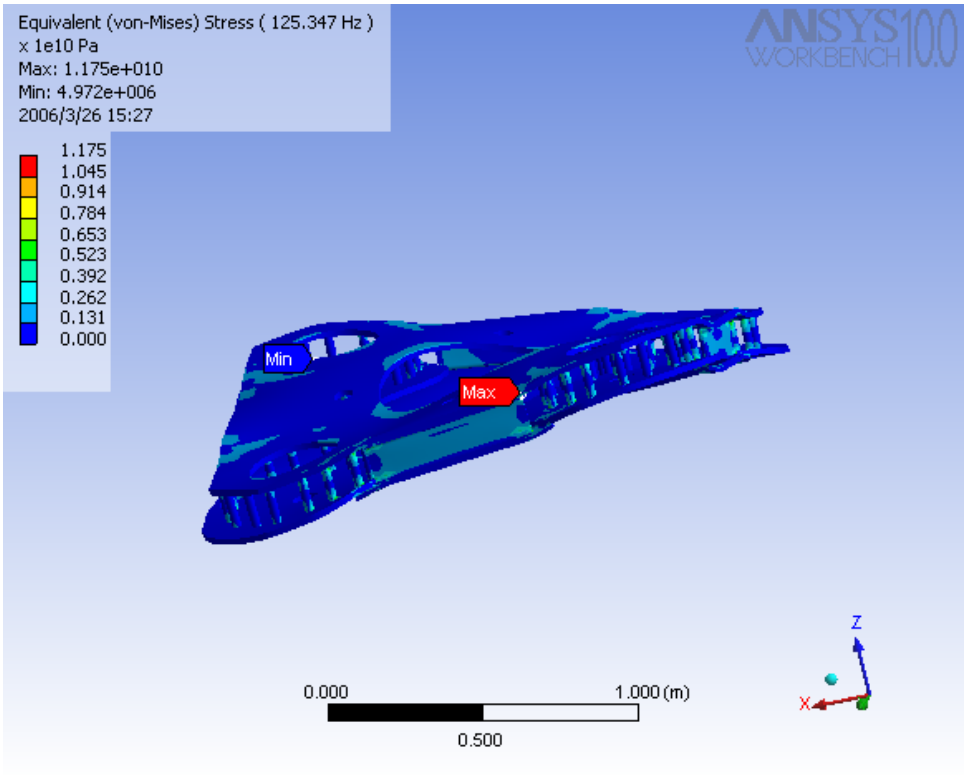
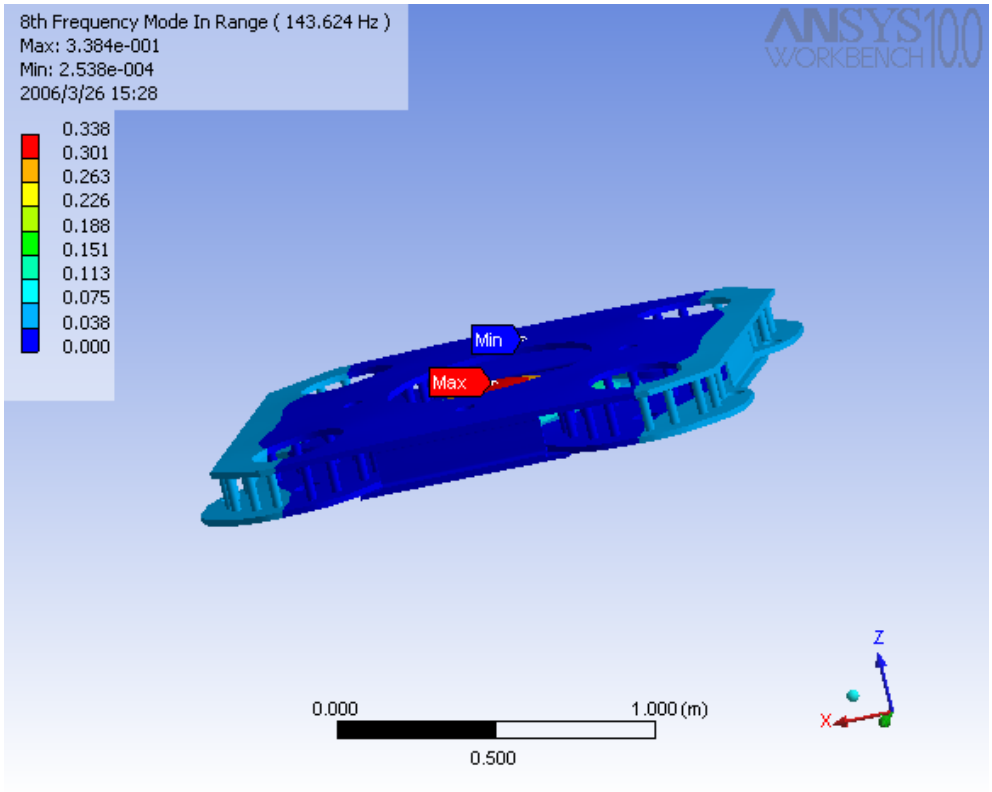


Figure 22, 7th cut perimeter



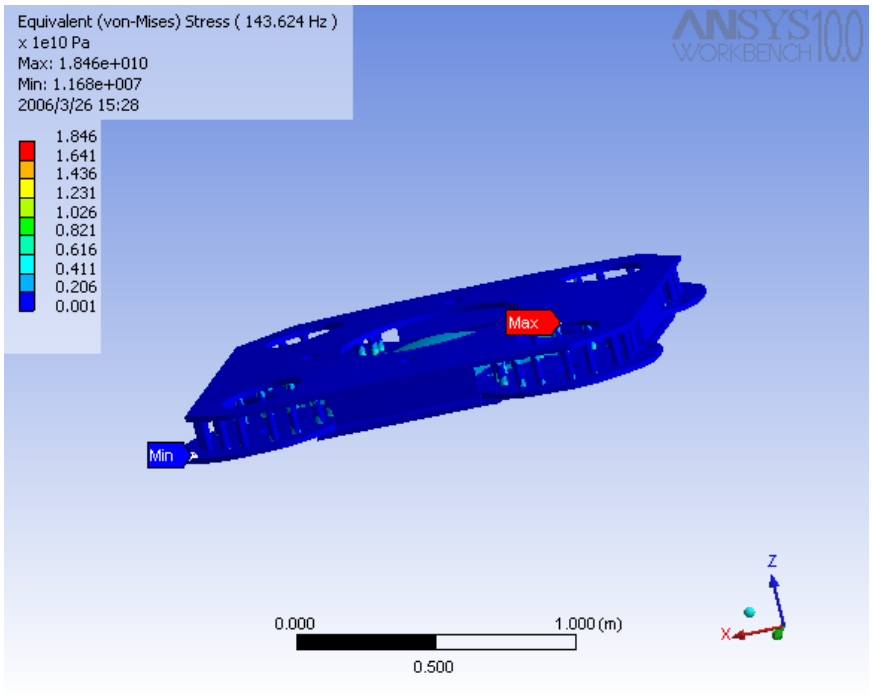


Figure 23, 8th cut perimeter

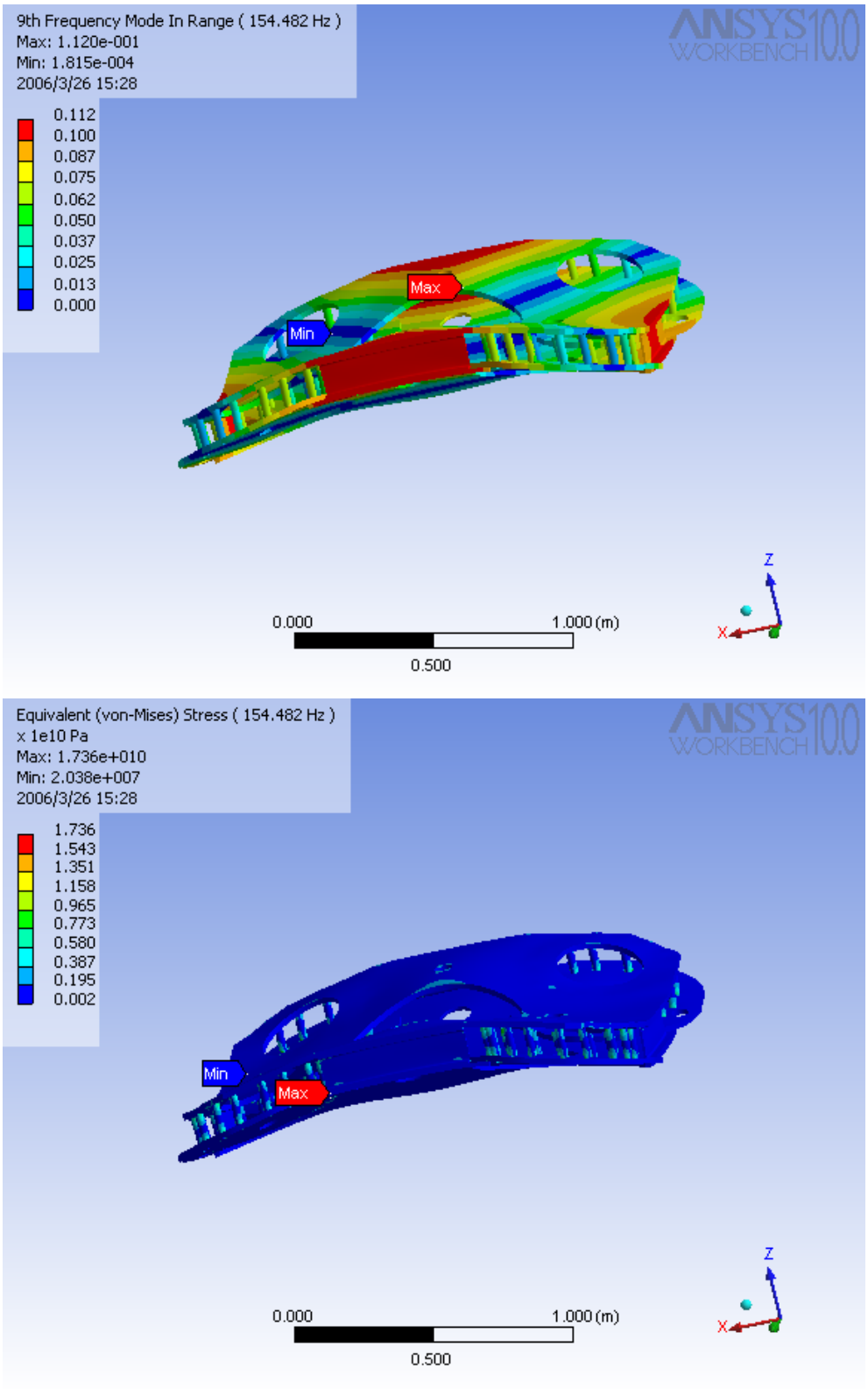


Figure 24, 9th cut perimeter

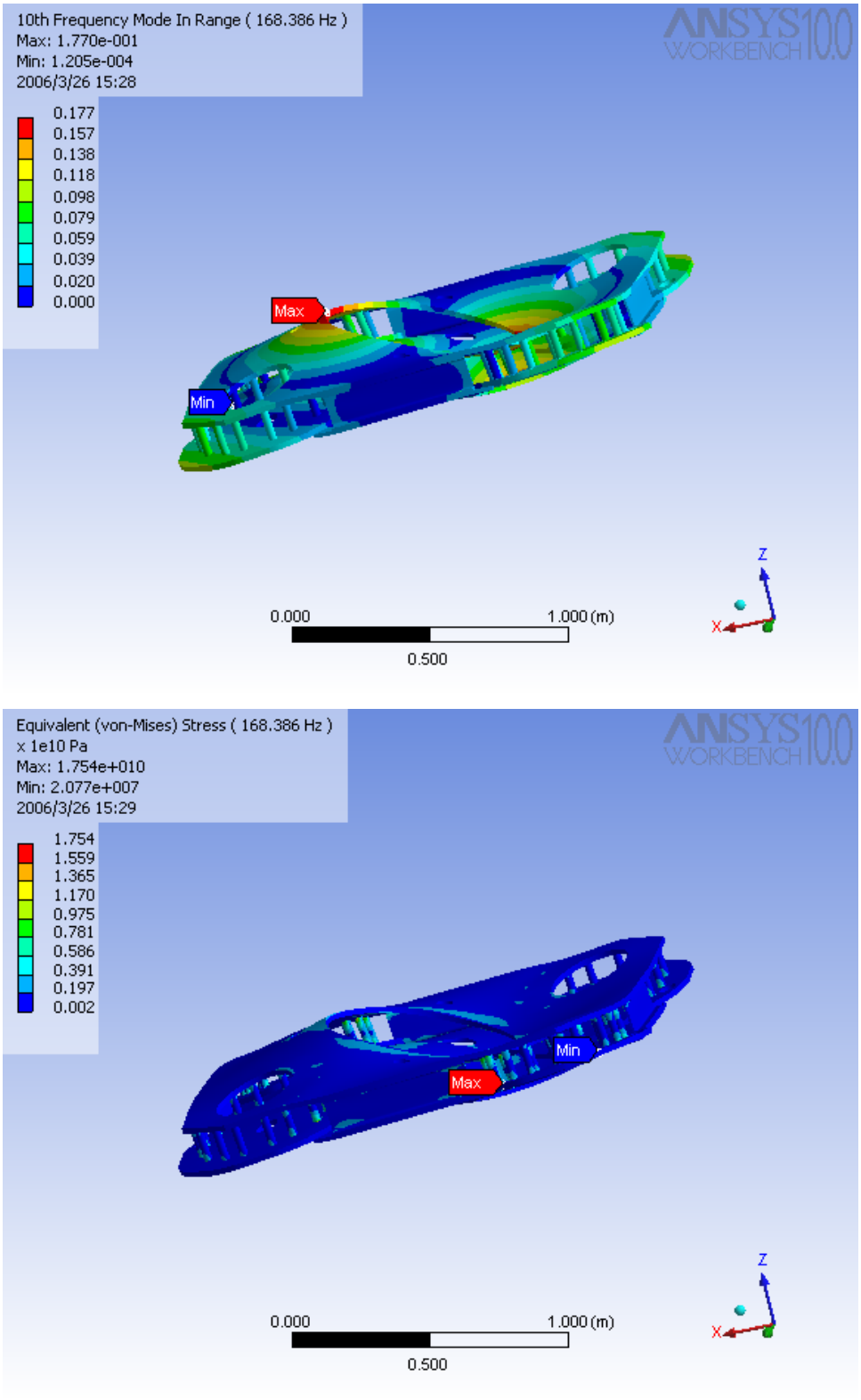


Figure 25, 10th cut perimeter