

# Preventing Negative Volume Solid Elements in Foam Materials

Oct 2010

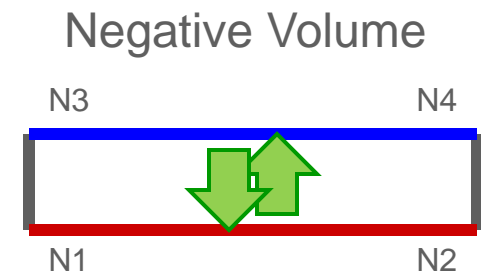
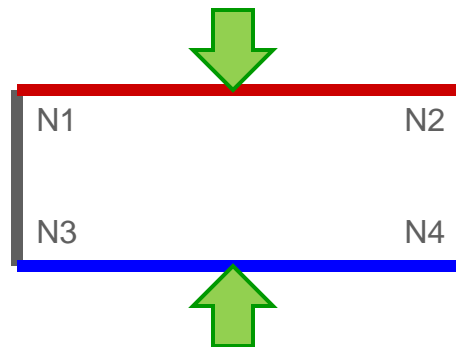
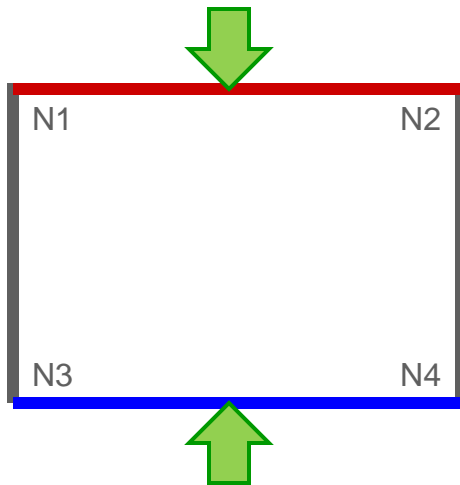
A typical error that can occur when modelling a foam material subjected to high loads and a large amount of compression is negative volume in the solid elements. This is where one face of a solid element passes through the other face.

### Error report from the log file

```
110000 t 2.7432E-02 dt 4.38E-09 flush i/o buffers  
115000 t 2.7454E-02 dt 5.81E-09 flush i/o buffers
```

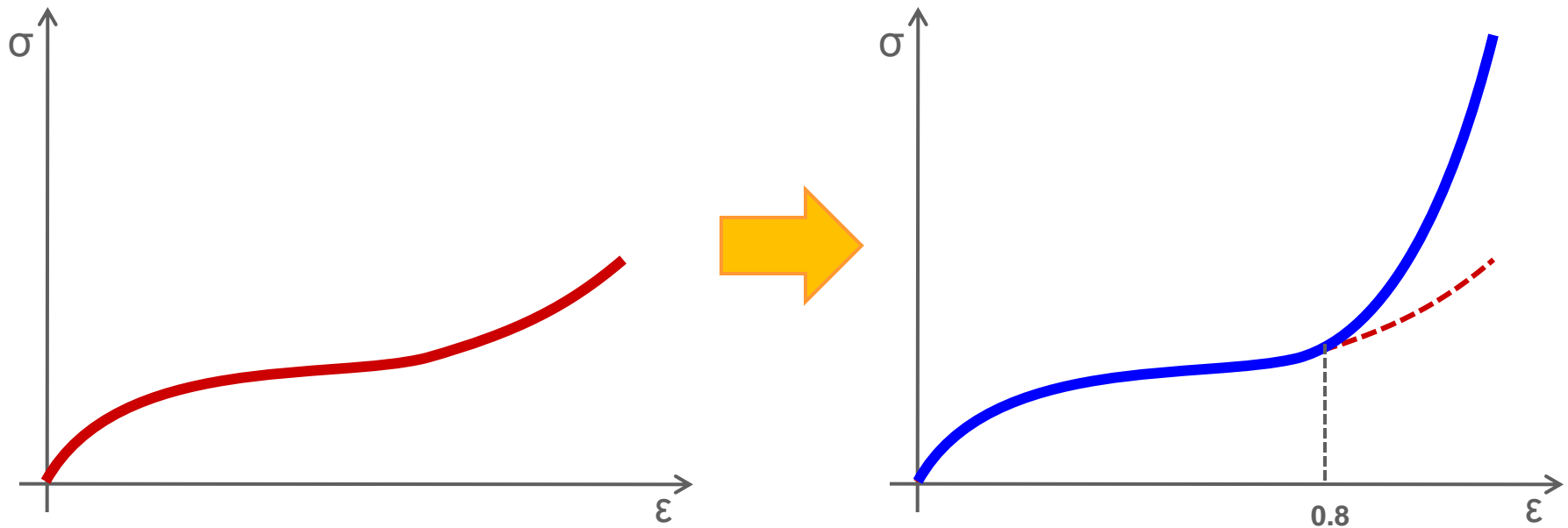
```
*** Error negative volume in solid element #    3719 cycle  119373
```

```
*** Error complex sound speed in solid element #    3719 cycle  119373
```



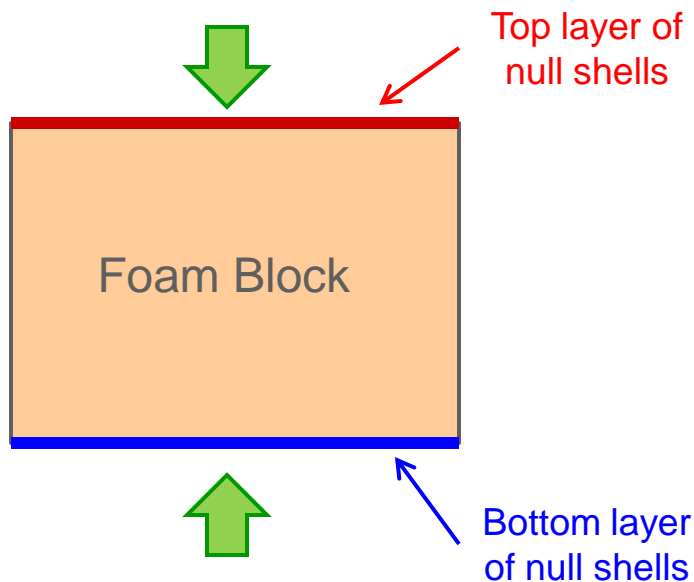
One method to solve this problem is to increase the stiffness of the foam material as it starts to lock up at about 80-90% crush (strain = 0.8-0.9).

This is done by editing the stress-strain curve used for the foam material.



Another method is to put a layer of null shell on the top and bottom (front/back) faces of the foam. A contact between these two layers of null shells is then used to prevent the solid elements from becoming too compressed.

The contact thickness between the two plates is set to about 10% of the thickness of the foam block so that the contact will act to lock up the foam block at 90% crush.



### Null Shell

Null shells are shell elements that use \*Mat\_Null.

Coating solid elements with null shells is when a shell element is created on a solid element face sharing the same nodes as the solid element.

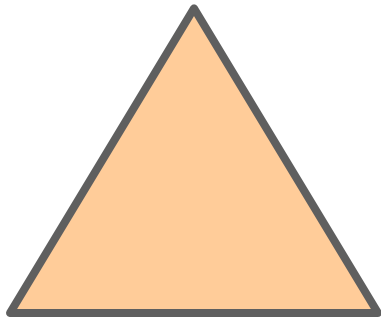
### Typical properties

Density = 0.1 \* foam density

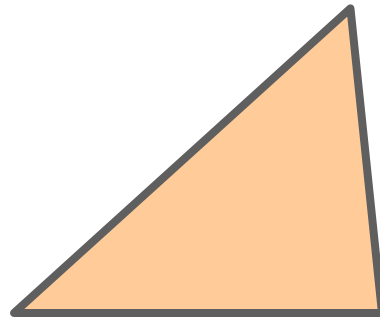
Youngs Modulus = 1Gpa

Thickness = 1mm

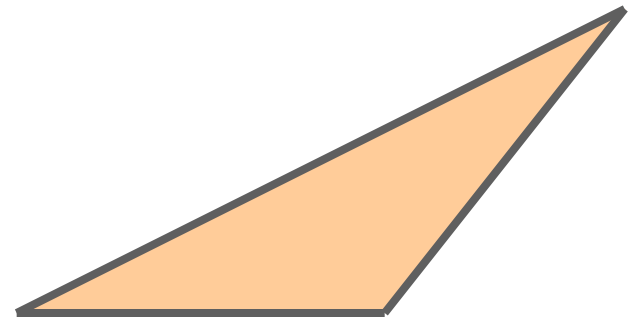
If the foam has been meshed with tetrahedron (tet) elements, then the stability can be improved by making sure the tet elements generated are reasonably regular and not skewed over.



Good

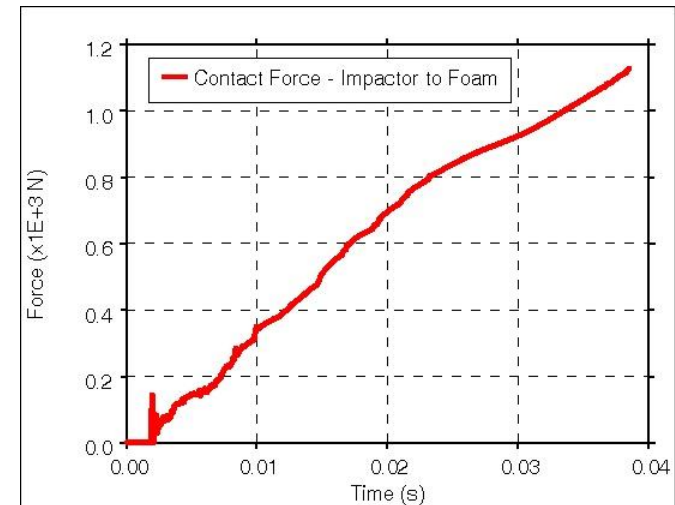
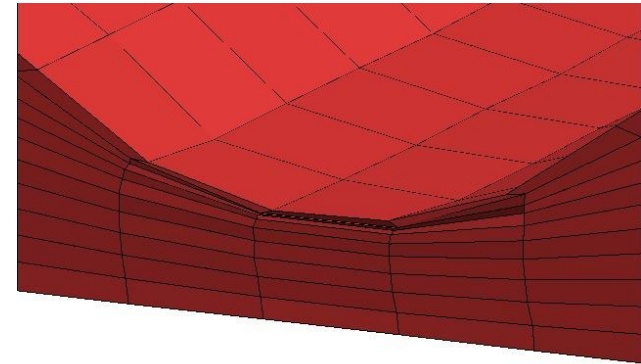
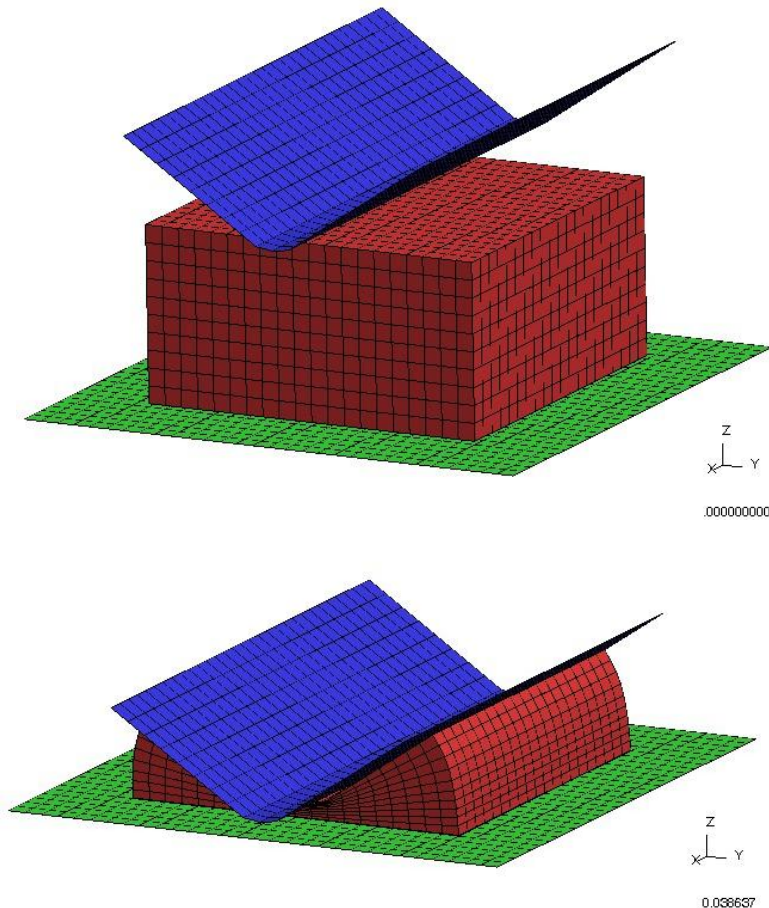


OK



Bad

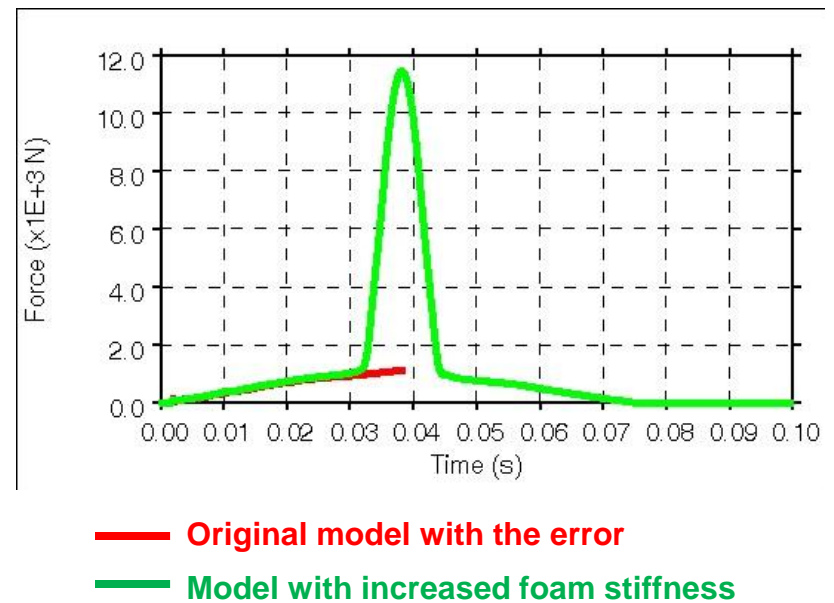
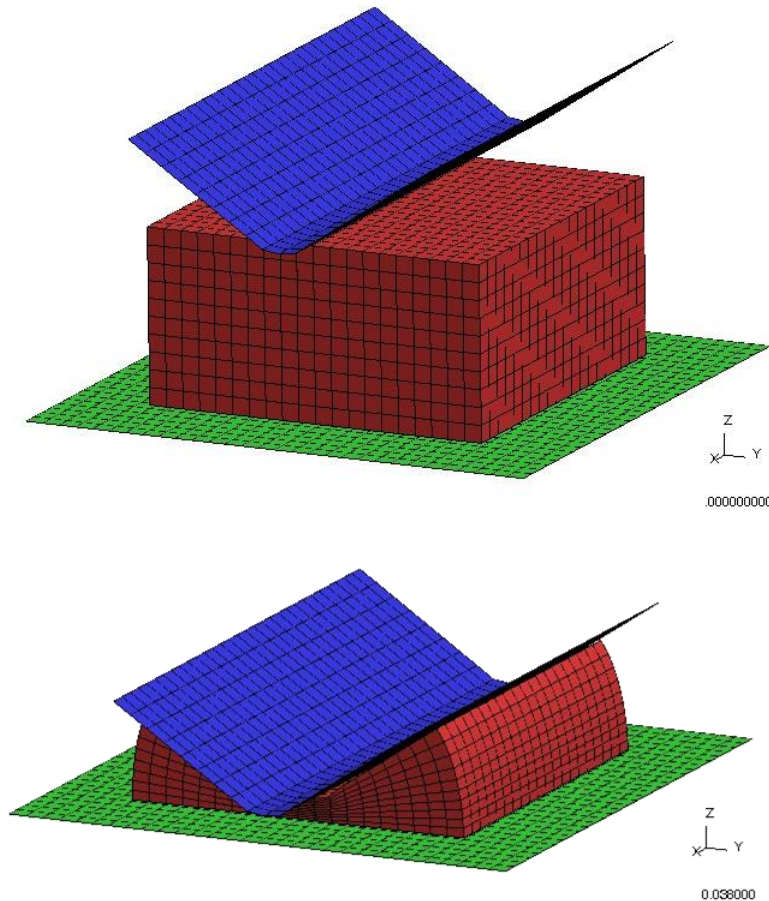
In this example a block of foam is crushed by a 20kg plate impacting a 3m/s. The model falls over at 38.6msec due to negative volume in the solid elements.



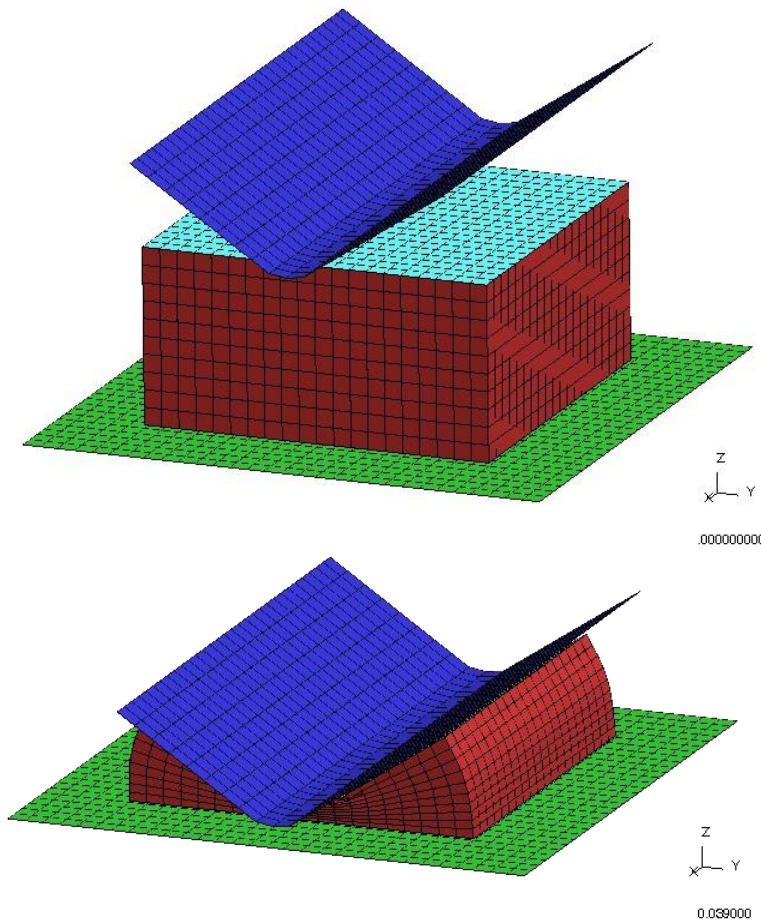


The stress-strain curve for the foam material has been modified to prevent the negative volumes.

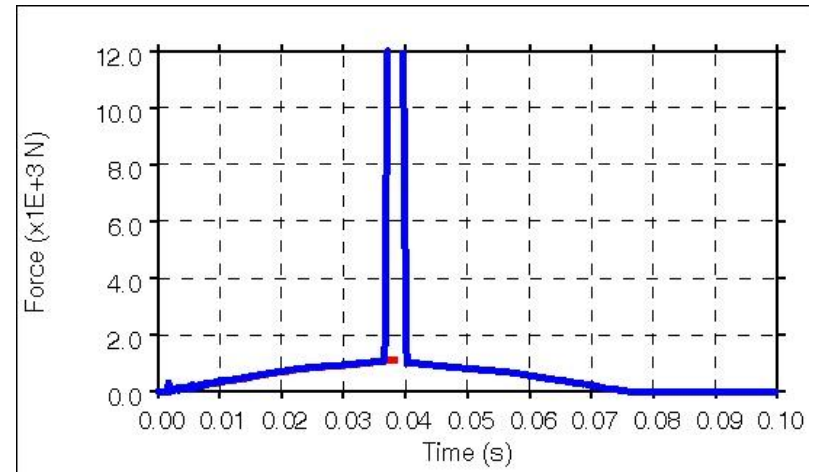
Contact force results showing both the loading and unloading phase



Null shells have been created on the top and bottom surface along with a contact between them.



Contact force results showing both the loading and unloading phase



— Original model with the error  
— Model with increased null shells added

The high peak load seen when the top and bottom layers come into contact can be reduced by lowering the Young's modulus of the null shells, the contact thickness may also need to be increased to prevent the contact from failing.  
(e.g. 100MPa and 15mm)





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