

Fermilab

PPD/MD/Engineering Analysis Group

**32 Planes with 4.5/3 mm Wall Thickness
For a Vertical Extrusion Only**

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This calculation is to study a case of the 32 planes with a vertical wall thickness being 4.5/3 mm while the horizontal remaining as 3/2 mm. Compared with 31 planes per block ^(1,2), 32 planes/block will have one side ending with the vertical and the another side ending with the horizontal. It will have a slightly un-symmetry in terms of the geometry and loading. The following boundary is used in the calculation:

- 1) A 19 psi linearly distributed pressure applied along the vertical cell and zero pressure for the horizontal.
- 2) The density is modified to reflect a proper weight of the PVC& liquid.
- 3) The bottom is assumed to be fixed as a worst case.
- 4) 32 planes as a block with a vertical ending for one side and horizontal ending for the other side.
- 5) The thickness of the adhesive is 10 mils with 0.5e6 psi as its modulus.

The calculation shows that the maximum deflection along the beam direction is about 0.38" for $E=0.146$ mpsi (4y) and 0.7435" for $E=0.075$ mpsi (20y), which is based on a pessimistic E curve for pet B. Compared with the case of the 31 planes/block, the deflection is increased by a factor of ~3.5 due to slightly un-symmetric geometry and loading. PVC stress is about same as the 31 planes case as shown in the Table 2. However, the shear stress in the adhesive layer goes as high as 240 psi. It occurs at the last interface where the horizontal ending is. It is probably due to the "cantilever" effect. The buckling calculation gives a similar result as the 31 planes/block, as shown in Table 3. Finally, a calculation is done for the 32 planes/block with an extra piece of the plate (4.5 mm thick) added around its bottom area to study the end cap effect. The result indicates that peak PVC stress goes away as expected while the adhesive stress remains the same as summarized in Table 5.

Table 1 Maximum Deflection along the beam line

	E=0.146 mpsi (4y)	E=0.075 mpsi (20y)
32 planes/per block	0.3822	0.7435
31 planes/per block	0.11	0.216

Note: E=0.146 mpsi (4y) and E=0.075 mpsi (20y) are based on the pessimistic E creep curve for PET B material

Table 2 Stress for the 32 planes/block
for E=0.075 mpsi (20y)

	PVC Stress		Adhesive stress	
	Peak (psi)	Excluding peak (psi)	Shear stress (psi)	Peeling force (lbf/in)
32 planes/block	766	489	240	4.80
31 planes/block	776	497	162	4.31

Table 3 SF of Buckling for 32 planes/block
(E=0.075 mpsi_ 20 y)

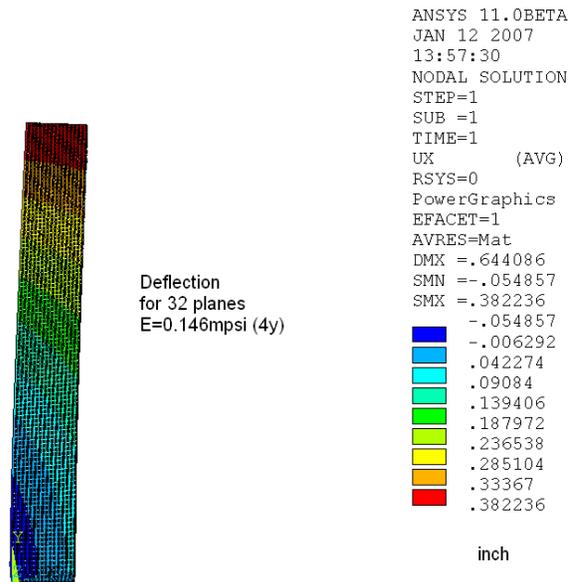
SF	Top free	Top guided
32 planes/block	0.94	1.129
31 planes/block	0.93	1.173

Table 4 Adhesive Stress (E=0.075 mpsi)

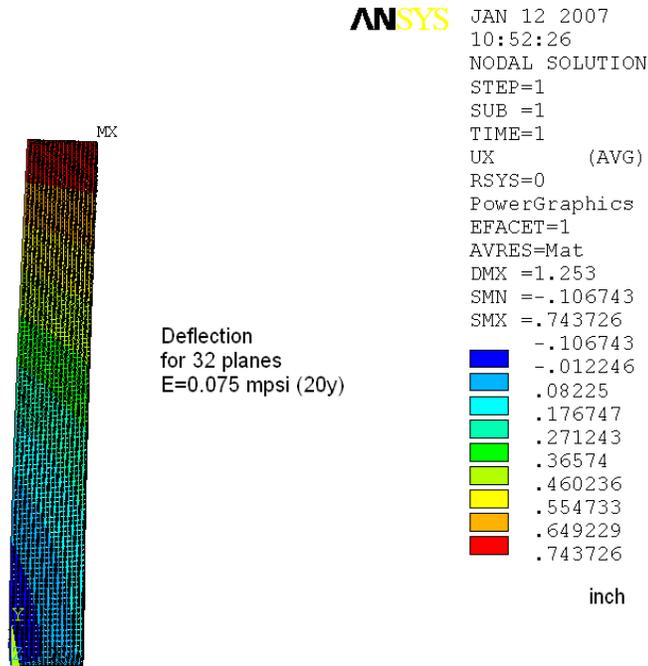
	Shear stress (psi)	Peeling force (lbf/in)
32 planes/block	240	4.8
31 planes/block	162	4.2

Table 5 Stress & Deflection for 32 planes/block
 with an extra piece of the plate (4.5mm thick)
 added around its bottom area (0.375"~9.5 mm high from ground);E=0.075 mpsi

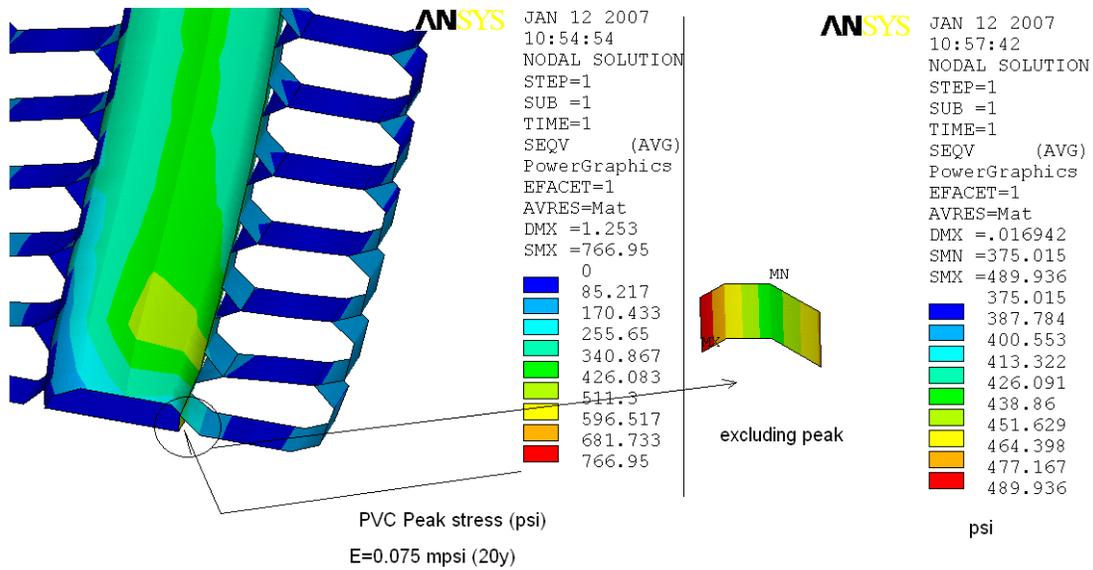
	Deflection (inch)	PVC stress (psi)	Shear stress in the adhesive (psi)	Peeling force (lbf/in)
32 planes/block	0.755	547	239	4.35



**Fig 1a Deflection along the beam direction E=0.146 mpsi (4y)
 (4.5mm/3mm for vertical only)**



**Fig 1b Deflection along the beam direction E=0.075 mpsi (20y)
(4.5mm/3mm for vertical only)**



**Fig 2a Stress near the bottom for 32 plane/block
(4.5mm/3mm for vertical only; E=0.075 mpsi _20y)**

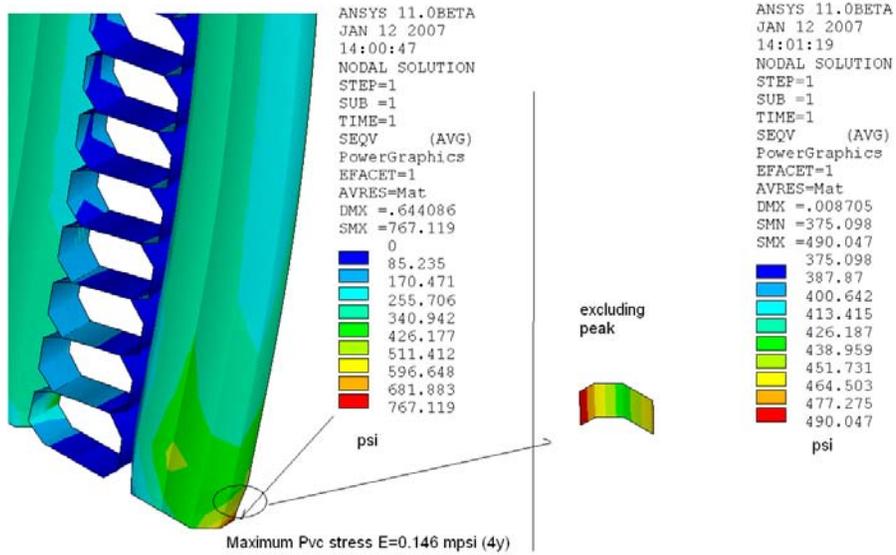


Fig 2b Stress near the bottom (4.5mm/3mm for vertical only)

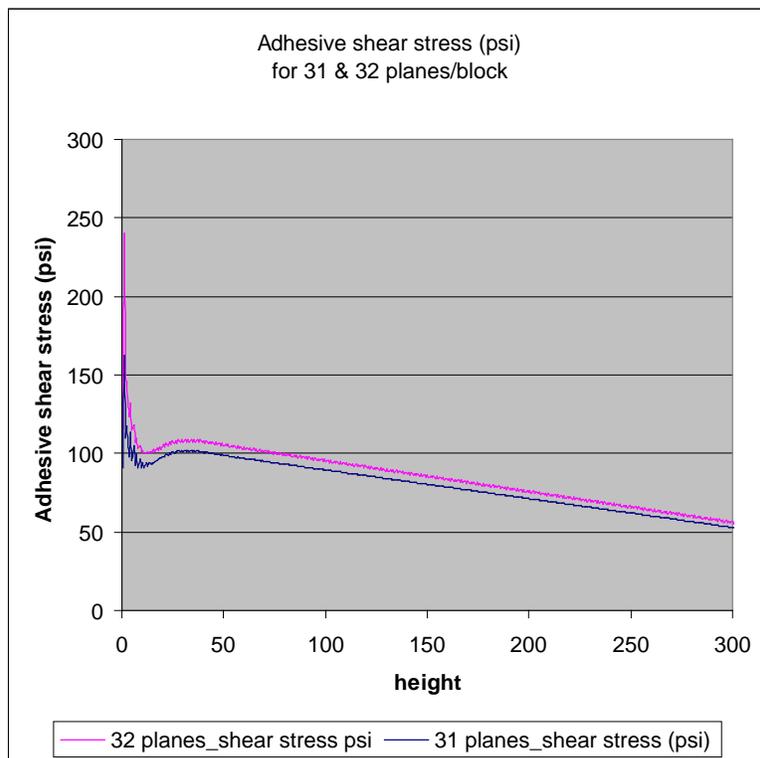


Fig 3a Adhesive stress __ first 300" from ground

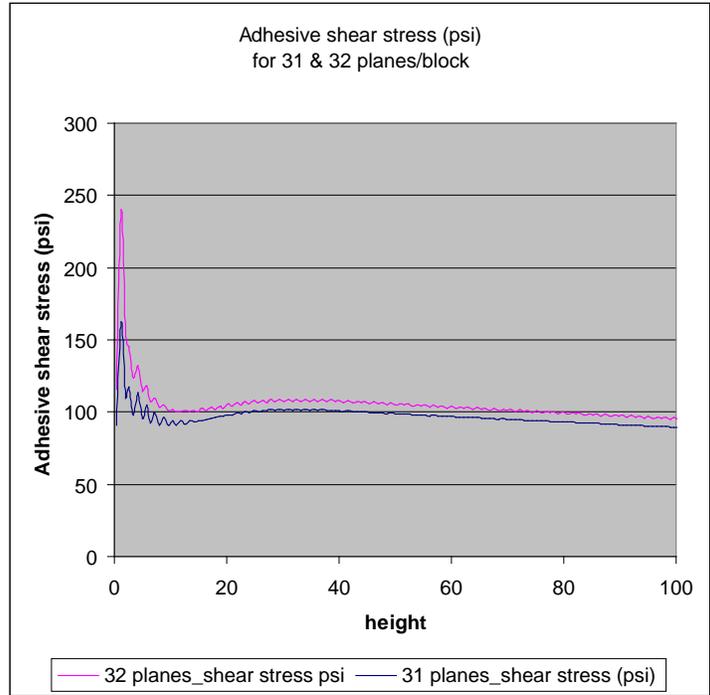


Fig 3b Adhesive stress __ first 100'' from ground

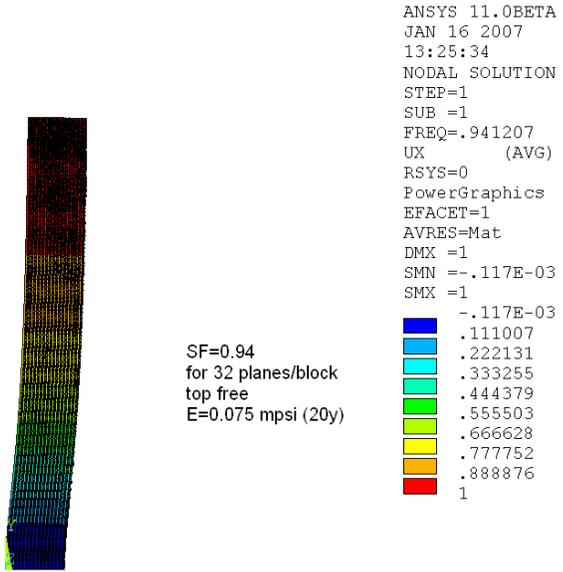


Fig 4 Buckling SF for 32 planes block ; E=0.075 mpsi; top free (4.5mm/3mm for the vertical extrusion)

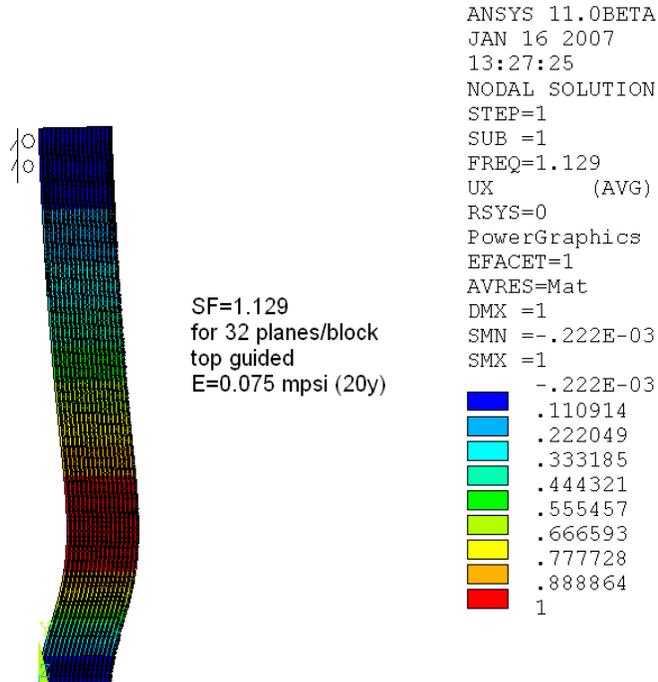


Fig 5 Buckling SF for 32 planes block ; E=0.075 mpsi; top guided (4.5mm/3mm for the vertical extrusion)

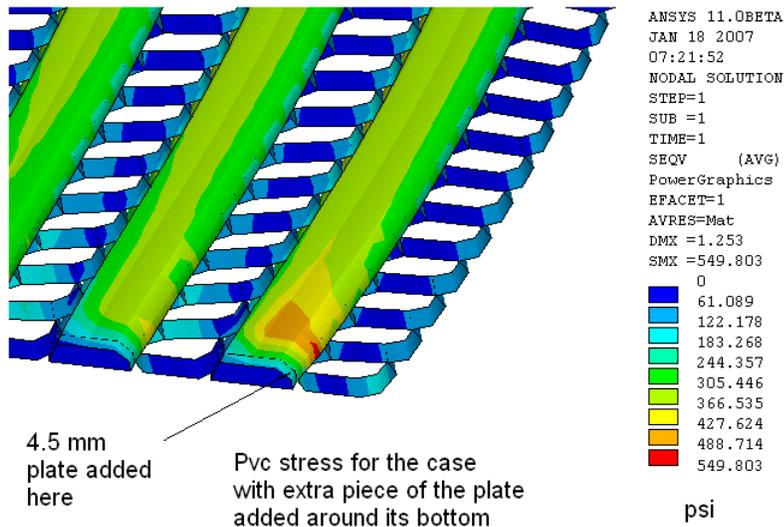


Fig 6 PVC stress for 32 planes with an extra piece of plate added around its bottom area

Reference

1) A Lee, " A Structural Calculation for 31 layers Block by Using a Pessimistic E Curve ", Oct,11,2006, Nova-docdb-1172

2) A Lee, " A Stress and Deflection as a Function of the Number of Planes in a Block with $E(4y)=0.146$ mpsi" ,Nov 21, 2006, Nova-docdb-1297