

**Fermilab**

**PPD/MD/Engineering Analysis Group**

**Stress Calculation For a Procedure of Filling Horizontal Plane First**

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The calculation is to understand both stress and stability issue for the case of filling horizontal plane first. Since the structure is designed for an operating condition in which both horizontal and vertical planes are filled, "filling the horizontal plane first" should not create any additional stress other than a fully loaded condition.

Calculation starts with 31 planes blocks with 2, 4, 8, 12 and 15 horizontal filled. The result is summarized in Table 1. It indicates that there will be a off-set deflection if the filling starts from one side of the block due to the uneven loading as shown in Fig 1. It reaches a peak value of 2.2" when the 8 out of the 15 horizontal planes filled. Then it levels off as soon as the other half of structure starts the oil filling. Finally, a structure reaches a symmetry condition with 15 horizontal planes completely filled. The stress for PVC is relatively low < 240 psi (peak). The adhesive stress is less than 60 psi for shear and less than < 1 lbf/in for the peeling force, respectively.

As an extension of the study, we expand the model to a 99 planes block with 49 horizontal and 50 vertical. Table 2 is a calculation result. Comparison shows that the off-set deflection (one side) seems getting better as the block size increased. Stress implication is minimum. As a conclusion, "filling the horizontal plane first" won't compromise the structure integrity since the block is designed for a full loading case.

**Table 1 Result for a Filling horizontal first for 31 planes block  
(15 horizontal+16 vertical) with E=0.075 mpsi**

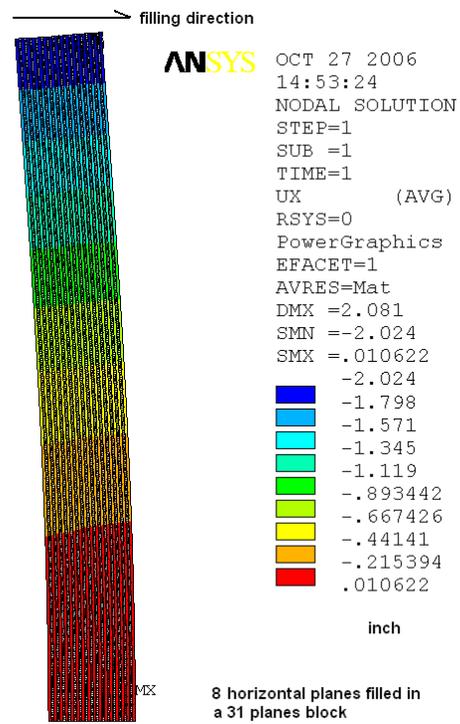
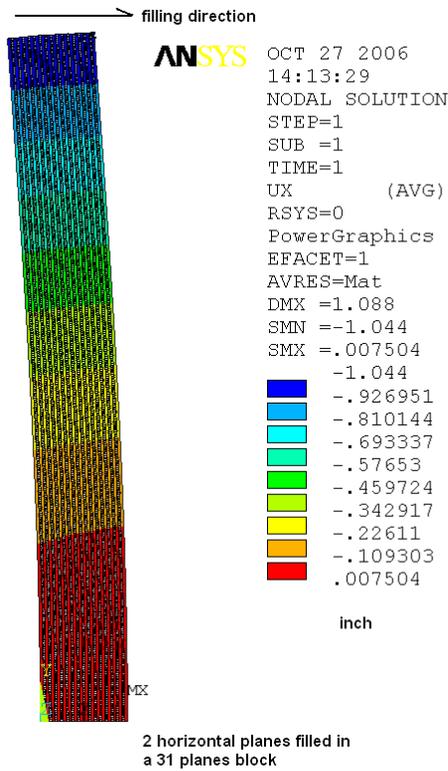
<b>Number of horizontal filled</b>	<b>2</b>	<b>4</b>	<b>8</b>	<b>12</b>	<b>15</b>
<b>Deflection (inch)</b>	<b>1.04</b>	<b>1.658</b>	<b>2.204</b>	<b>1.396</b>	<b>0.025</b>
<b>Stress peak (psi)</b>	<b>149</b>	<b>190</b>	<b>231</b>	<b>239</b>	<b>223</b>
<b>Stress excluding peak (psi)</b>	<b>113</b>	<b>143</b>	<b>174</b>	<b>179</b>	<b>166</b>
<b>Shear stress psi</b>	<b>27.39</b>	<b>34.80</b>	<b>41.73</b>	<b>42.13</b>	<b>57.20</b>
<b>Peeling force lbf/in</b>	<b>0.54</b>	<b>0.64</b>	<b>0.50</b>	<b>0.67</b>	<b>0.30</b>
<b>SF of buckling (E=0.075 mpsi)</b>	<b>4.45</b>		<b>2.79</b>		<b>1.964</b>

**Table 2 Result for a Filling horizontal first for 99 planes block  
(49 horizontal+50 vertical) with E=0.075 mpsi**

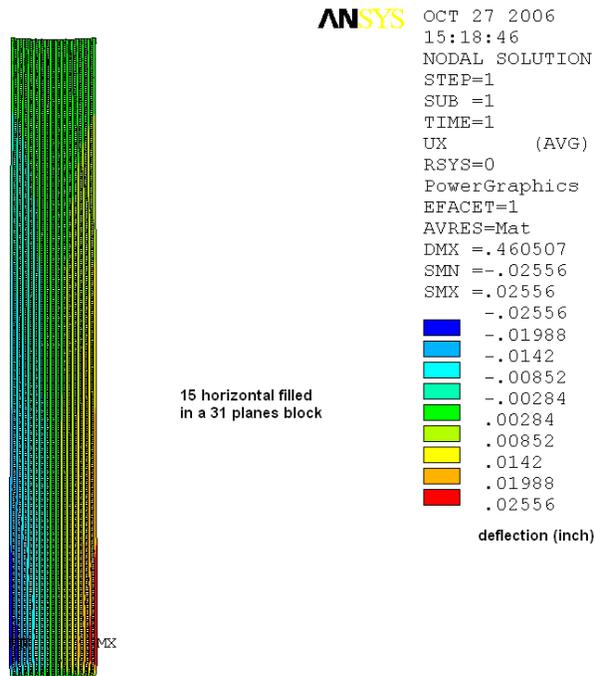
<b>Number of horizontal filled</b>	<b>8</b>	<b>16</b>	<b>24</b>	<b>49</b>
<b>Deflection (inch)</b>	<b>0.48</b>	<b>0.56</b>	<b>0.57</b>	<b>0.079</b>
<b>Stress peak (psi)</b>	<b>222</b>	<b>254</b>	<b>266</b>	<b>264</b>
<b>Stress excluding peak (psi)</b>	<b>166</b>	<b>190</b>	<b>199</b>	<b>198</b>
<b>Shear stress (psi)</b>	<b>39.33</b>	<b>44.80</b>	<b>46.80</b>	<b>69.33</b>
<b>Peeling force (lbf/in)</b>	<b>1.34</b>	<b>1.02</b>	<b>1.09</b>	<b>0.53</b>

Table 3 Comparison for 31 planes and 99 planes block

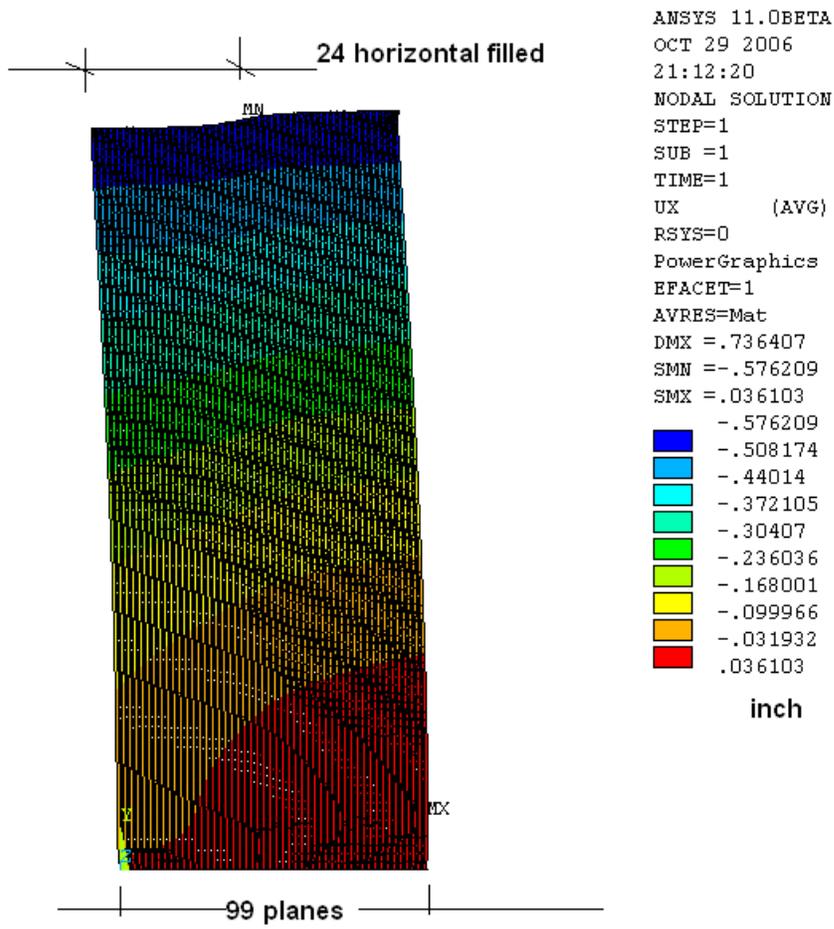
	Deflection (inch)	PVC Stress (peak) psi	PVC Stress (excluding peak) psi	Adhesive Shear (psi)	Adhesive Peeling (lbf/in)
31 planes block with 15 horizontal filled	0.025	223	166	57.2	0.3
99 planes block With 49 horizontal filled	0.079	264	198	69.33	0.53



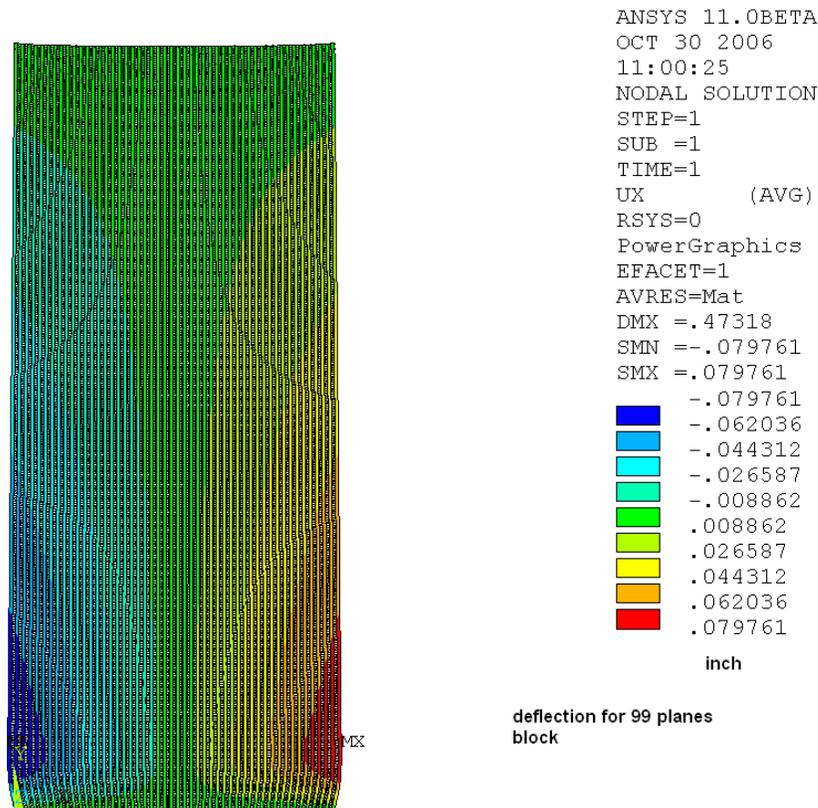
**Fig 1 Deflection for 2 & 8 horizontal planes filled in 31 planes block**



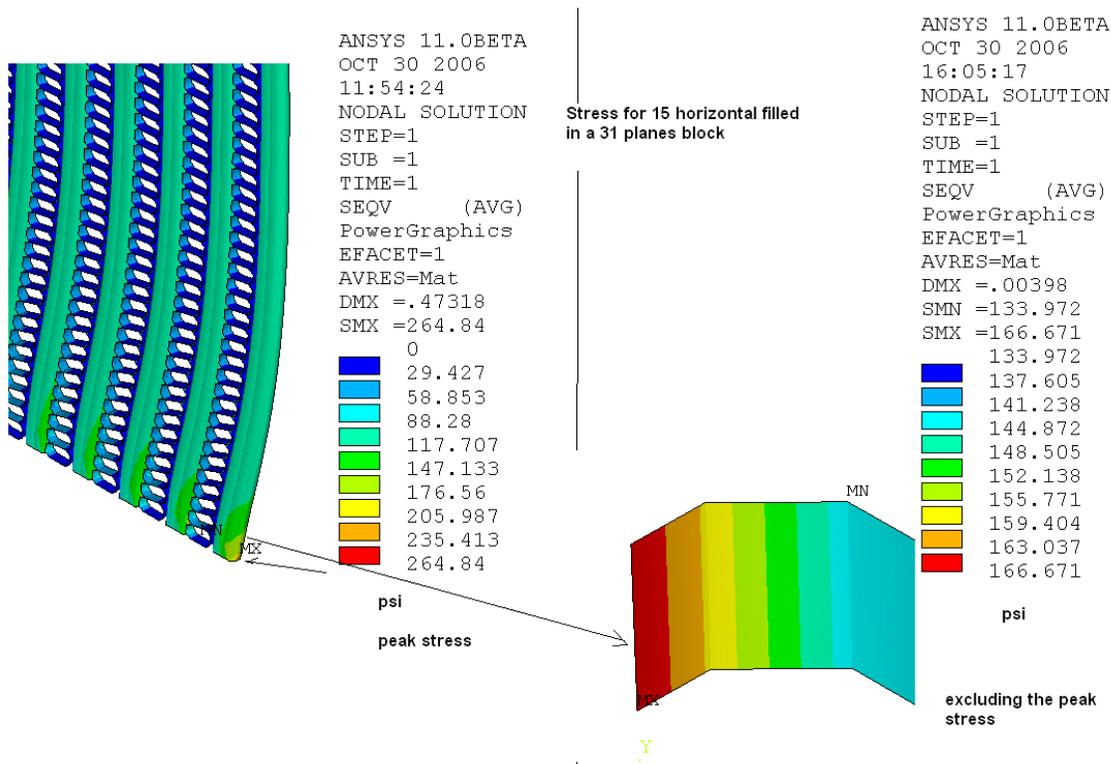
**Fig 2 Deflection for 15 horizontal filled in a 31 planes**



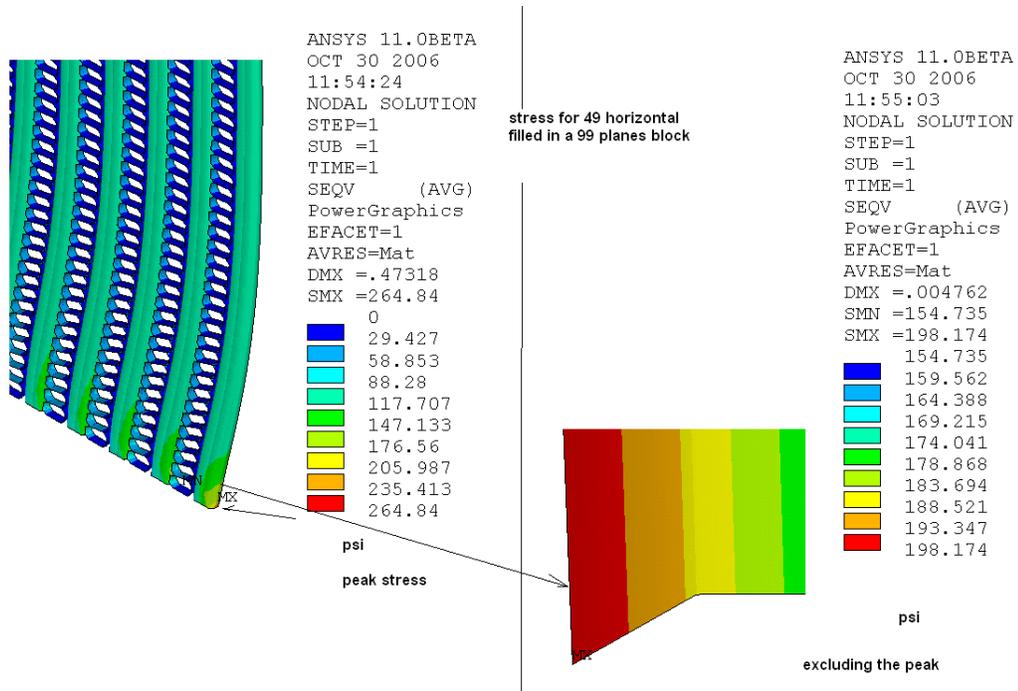
**Fig 3 Deflection for 24 horizontal filled in a 99 planes block**



**Fig 4 Deflection for 99 planes with 49 horizontal filled**



**Fig 5 Stress for 15 horizontal filled in 31 block**



**Fig 6 Stress for 49 horizontal filled in 99 planes block**