TIPS AND TRICKS: LAYUP OPTIMIZATION WITH LAP STEP BY STEP

About LAP

LAP is a Windows software tool for the **analysis and design of composite material laminates.**

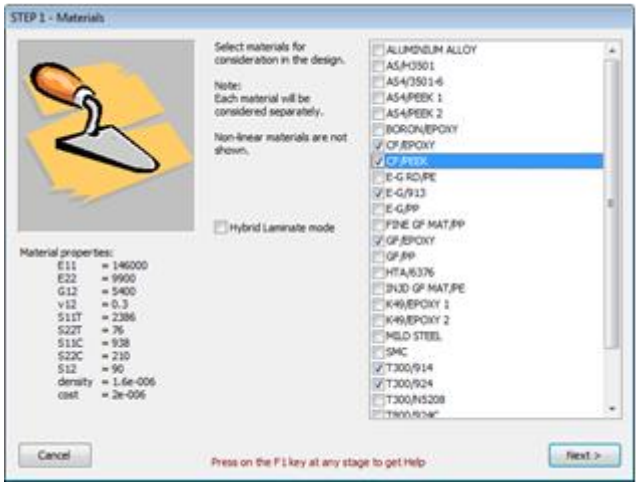
Several years of active presence in the international composites community have established LAP as the most user friendly and powerful tool in its class. LAP is used by designers and researchers alike in more than 25 countries across the world.

The Laminate Analysis Program can be used to analyze any type of composite laminate subjected to in-plane and transverse loads and moments. The flat laminate has no fixed size apart from its thickness, so that the analysis can be applied to any composite component, at a location where loadings or deformations are known.

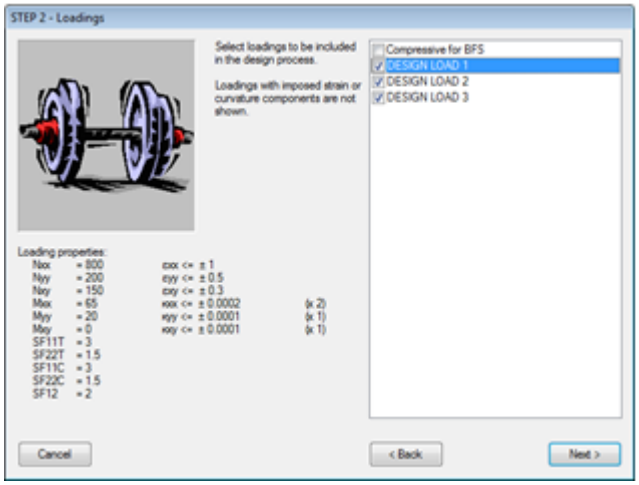
Challenge Objective

How to create the optimal layups, based on your design requirements. This way you will ensure best use of material, make structure as light as possible, avoid design iterations and prepare the ground for efficient use of HyperWorks

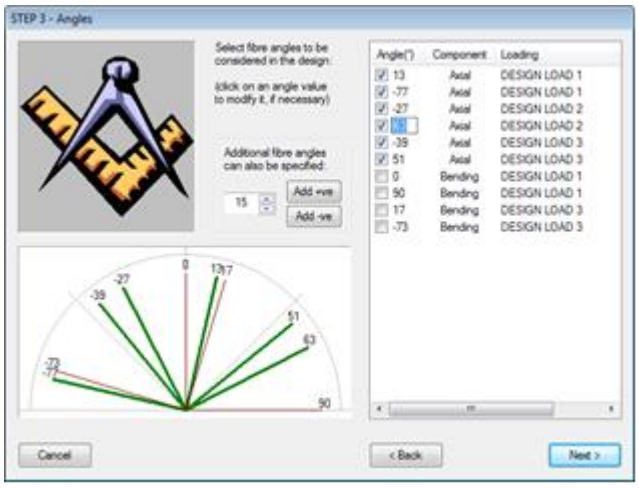
1. Step 1: Select the candidate materials, typical design loads



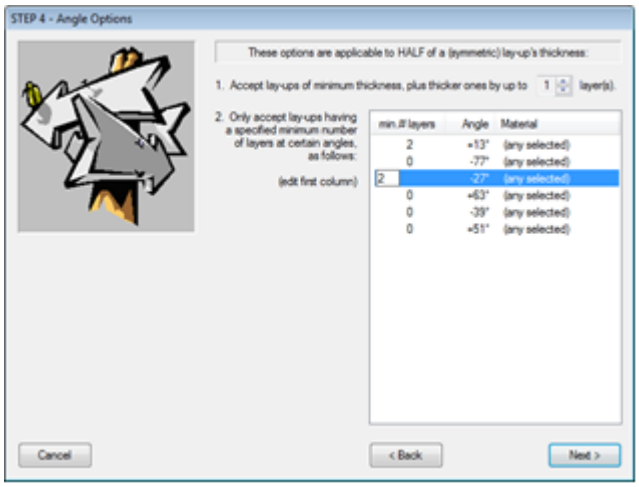
2. Step 2: Select the loading that must each be satisfied in the final laminates



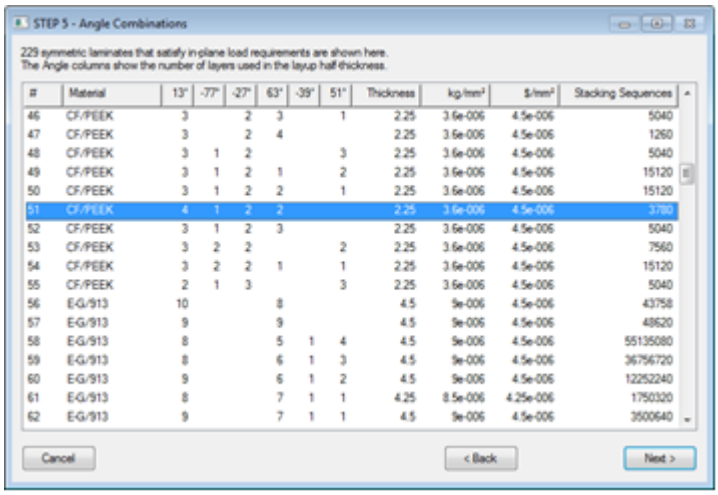
3. Step 3: Select fiber angles that will be considered in the first stage of design (to satisfy axial loads)



4. Step 4: Certain options may be applied prior to initiating the first design calculation

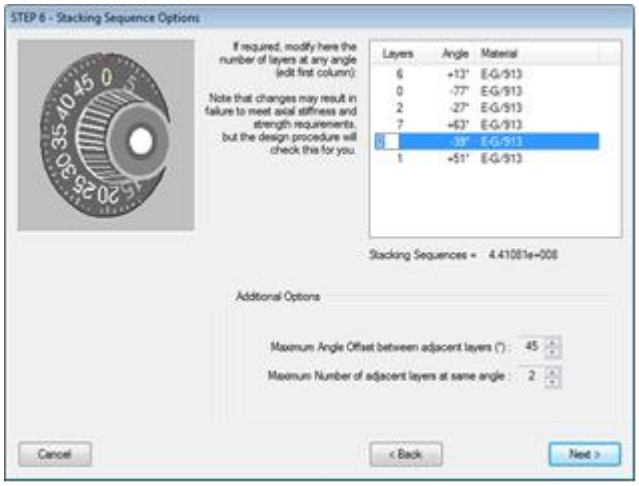


5. Step 5: The successful combinations of angles are shown, for each candidate material or for the hybrid

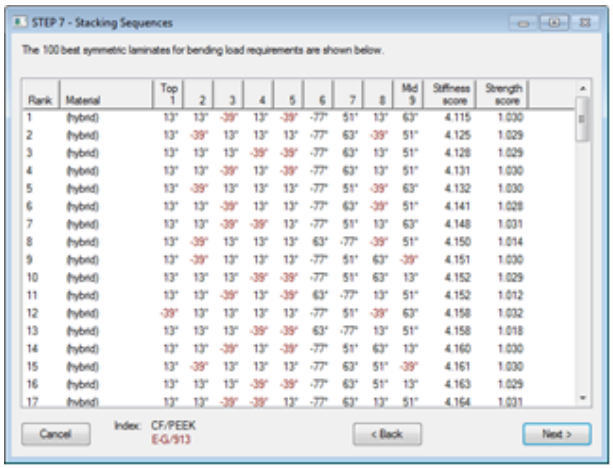


#	Material	13°	-77°	-27°	63°	-39°	51°	Thickness	kg/mm²	$/mm²	Stacking Sequences
46	CF/PEEK	3		2	3		1	2.25	3.6e-006	4.5e-006	5040
47	CF/PEEK	3		2	4			2.25	3.6e-006	4.5e-006	1260
48	CF/PEEK	3	1	2			3	2.25	3.6e-006	4.5e-006	5040
49	CF/PEEK	3	1	2	1		2	2.25	3.6e-006	4.5e-006	15120
50	CF/PEEK	3	1	2	2		1	2.25	3.6e-006	4.5e-006	15120
51	CF/PEEK	4	1	2	2			2.25	3.6e-006	4.5e-006	3780
52	CF/PEEK	3	1	2	3			2.25	3.6e-006	4.5e-006	5040
53	CF/PEEK	3	2	2			2	2.25	3.6e-006	4.5e-006	7560
54	CF/PEEK	3	2	2	1		1	2.25	3.6e-006	4.5e-006	15120
55	CF/PEEK	2	1	3			3	2.25	3.6e-006	4.5e-006	5040
56	E-G/913	10			8			4.5	9e-006	4.5e-006	43758
57	E-G/913	9			9			4.5	9e-006	4.5e-006	48620
58	E-G/913	8			5	1	4	4.5	9e-006	4.5e-006	55135080
59	E-G/913	8			6	1	3	4.5	9e-006	4.5e-006	36756720
60	E-G/913	9			6	1	2	4.5	9e-006	4.5e-006	12252240
61	E-G/913	8			7	1	1	4.25	8.5e-006	4.25e-006	1750320
62	E-G/913	9			7	1	1	4.5	9e-006	4.5e-006	3500640

6. Step 6: Stacking Sequence Options: The next calculation step consists of building stacking sequences, based on the selection of angle combinations made in Step 5

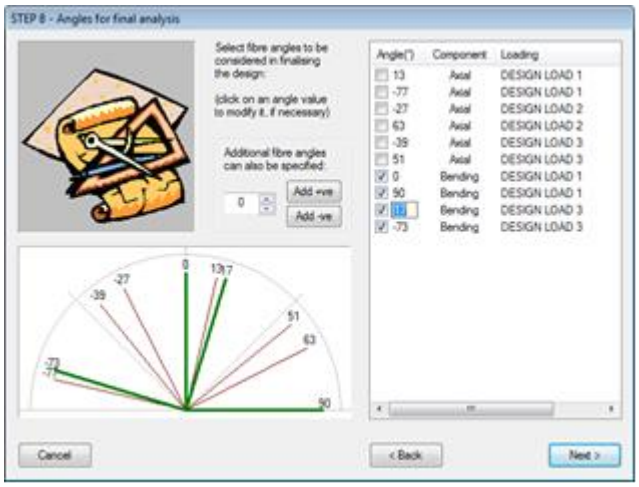


7. Step 7: Stacking sequence: Following a rigorous examination of the possible ways to stack the specified number of layers at different angles, the best stacking sequences are presented here

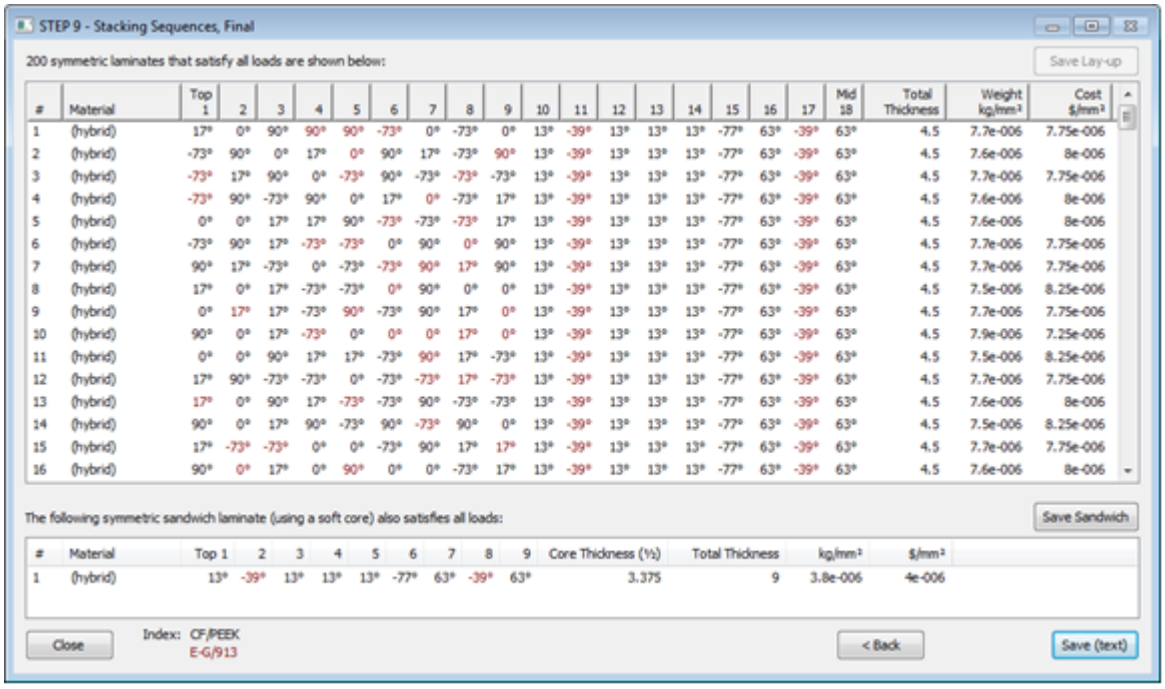


Rank	Material	Top 1	2	3	4	5	6	7	8	Mid 9	Stiffness score	Strength score
1	(hybrid)	13°	13°	-39°	13°	-39°	-77°	51°	13°	63°	4.115	1.030
2	(hybrid)	13°	-39°	13°	13°	13°	-77°	63°	-39°	51°	4.125	1.029
3	(hybrid)	13°	13°	13°	-39°	-39°	-77°	63°	13°	51°	4.128	1.029
4	(hybrid)	13°	13°	-39°	13°	-39°	-77°	63°	13°	51°	4.131	1.030
5	(hybrid)	13°	-39°	13°	13°	13°	-77°	51°	-39°	63°	4.132	1.030
6	(hybrid)	13°	13°	-39°	13°	13°	-77°	63°	-39°	51°	4.141	1.028
7	(hybrid)	13°	13°	-39°	-39°	13°	-77°	51°	13°	63°	4.148	1.031
8	(hybrid)	13°	-39°	13°	13°	13°	63°	-77°	-39°	51°	4.150	1.014
9	(hybrid)	13°	-39°	13°	13°	13°	-77°	51°	63°	-39°	4.151	1.030
10	(hybrid)	13°	13°	13°	-39°	-39°	-77°	51°	63°	13°	4.152	1.029
11	(hybrid)	13°	13°	-39°	13°	-39°	63°	-77°	13°	51°	4.152	1.012
12	(hybrid)	-39°	13°	13°	13°	13°	-77°	51°	-39°	63°	4.158	1.032
13	(hybrid)	13°	13°	13°	-39°	-39°	63°	-77°	13°	51°	4.158	1.018
14	(hybrid)	13°	13°	-39°	13°	-39°	-77°	51°	63°	13°	4.160	1.030
15	(hybrid)	13°	-39°	13°	13°	13°	-77°	63°	51°	-39°	4.161	1.030
16	(hybrid)	13°	13°	13°	-39°	-39°	-77°	63°	51°	13°	4.163	1.029
17	(hybrid)	13°	13°	-39°	-39°	13°	-77°	63°	13°	51°	4.164	1.031

8. Step 8: Angles for final analysis: The final step in the design process consists of adding layers to the outside of the stacking sequence built and selected in the previous step.



9. Step 9: Stacking Sequence: Finally, a set of stacking sequences that satisfy all loading requirements is presented



#	Material	Top 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Mid 18	Total Thickness	Weight kg/mm³	Cost $/mm³
1	(hybrid)	17°	0°	90°	90°	90°	-73°	0°	-73°	0°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.7e-006	7.75e-006
2	(hybrid)	-73°	90°	0°	17°	0°	90°	17°	-73°	90°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.6e-006	8e-006
3	(hybrid)	-73°	17°	90°	0°	-73°	90°	-73°	-73°	-73°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.7e-006	7.75e-006
4	(hybrid)	-73°	90°	-73°	90°	0°	17°	0°	-73°	17°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.6e-006	8e-006
5	(hybrid)	0°	0°	17°	17°	90°	-73°	-73°	-73°	17°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.6e-006	8e-006
6	(hybrid)	-73°	90°	17°	-73°	-73°	0°	90°	0°	90°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.7e-006	7.75e-006
7	(hybrid)	90°	17°	-73°	0°	-73°	-73°	90°	17°	90°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.7e-006	7.75e-006
8	(hybrid)	17°	0°	17°	-73°	-73°	0°	90°	0°	0°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.5e-006	8.25e-006
9	(hybrid)	0°	17°	17°	-73°	90°	-73°	90°	17°	0°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.7e-006	7.75e-006
10	(hybrid)	90°	0°	17°	-73°	0°	0°	0°	17°	0°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.9e-006	7.25e-006
11	(hybrid)	0°	0°	90°	17°	17°	-73°	90°	17°	-73°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.5e-006	8.25e-006
12	(hybrid)	17°	90°	-73°	-73°	0°	-73°	-73°	17°	-73°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.7e-006	7.75e-006
13	(hybrid)	17°	0°	90°	17°	-73°	-73°	90°	-73°	-73°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.6e-006	8e-006
14	(hybrid)	90°	0°	17°	90°	-73°	90°	-73°	90°	0°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.5e-006	8.25e-006
15	(hybrid)	17°	-73°	-73°	0°	0°	-73°	90°	17°	17°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.7e-006	7.75e-006
16	(hybrid)	90°	0°	17°	0°	90°	0°	0°	-73°	17°	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	4.5	7.6e-006	8e-006

#	Material	Top 1	2	3	4	5	6	7	8	9	Core Thickness (½)	Total Thickness	kg/mm²	$/mm²
1	(hybrid)	13°	-39°	13°	13°	13°	-77°	63°	-39°	63°	3.375	9	3.8e-006	4e-006