Modal Analysis of a Composite Monocoque - Pre-Analysis & Start-Up

Author: Jingsi Wu, Cornell University

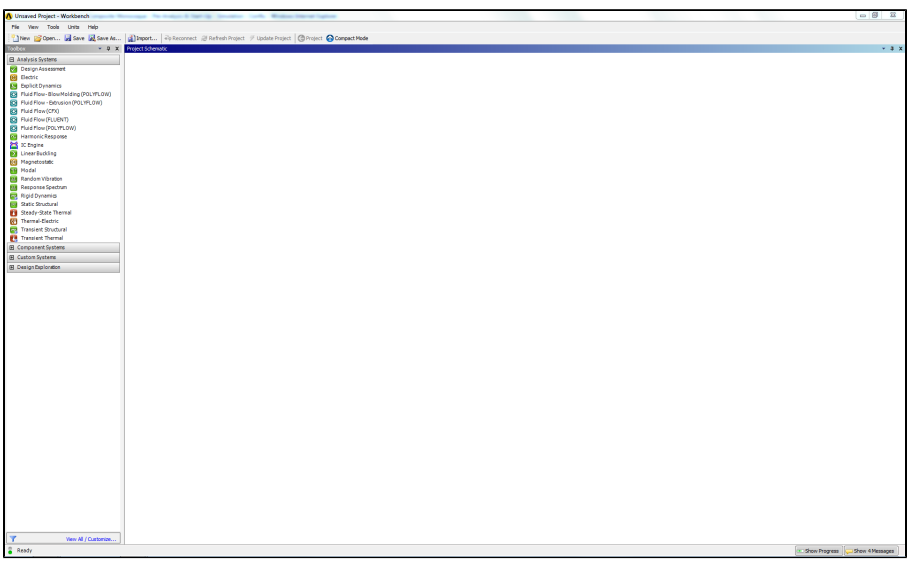
Pre-Analysis

The analytical calculation of the problem are explained in this PDF document. These passages are taken from the isotropic analysis section of "Design, Analysis and Testing of a Formula SAE Carbon Fiber Monocoque Chassis" by Jingsi Wu, Owusu A. Agyeman Badu, and Yongcheng Tai.

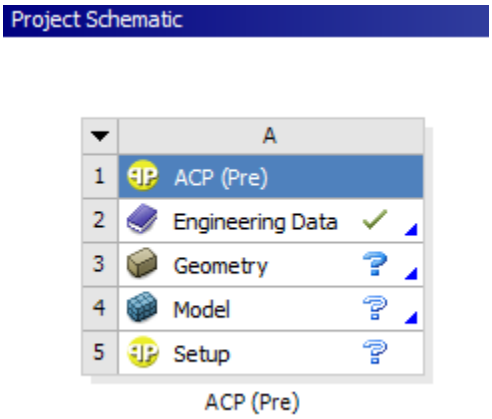
Start-Up

Open ANSYS Workbench

Open ANSYS Workbench by going to Start > All Programs > ANSYS 14.0 > Workbench 14.0. This will open the start up screen as seen below:



Expand ***Component Systems***, then drag ***ACP (Pre)*** to the Project Schematic window, as shown below.



Save the project and name it, *Modal Analysis of a Composite Monocoque*.

Set-up the Material Properties

The material properties for composite materials are different than typical isotropic materials, because some material properties depend on direction. Also, monocoque typically have a sandwich structure consisting of carbon fiber layups surrounding an aluminum core. The following steps show how to enter orthotropic properties into ANSYS.

T300 Weave

Double click ***Engineering Data***

Add a new material by click into the text box, and name the material "T300 weave".

To enter an orthotropic material property, go to ***Linear Elastic*** > (Drag) Orthotropic Elasticity onto the new material. A lists of property information will appear in the Property Outline as shown below:

Properties of Outline Row 4: T300

	A	B	C	D	E
1	Property	Value	Unit		
2	Orthotropic Elasticity				
3	Young's Modulus X direction		psi		
4	Young's Modulus Y direction		psi		
5	Young's Modulus Z direction		psi		
6	Poisson's Ratio XY				
7	Poisson's Ratio YZ				
8	Poisson's Ratio XZ				
9	Shear Modulus XY		psi		
10	Shear Modulus YZ		psi		
11	Shear Modulus XZ		psi		

Here are the corresponding properties for this material:

Ex = 8.5E6 psi
Ey = 8.5E6 psi
Ez = 1E6 psi
Vxy = 0.06
Vyz = 0.06
Vxz = 0.06
Gxy = 5.6E5 psi
Gyz = 5.6E5 psi
Gxz = 8.3E5 psi

This type of composite is weaved, so you have to define that as well, go to ***Physical Properties*** > (Drag) Density and Ply Type on to the new material. Enter 0.056 lb/in^3 for the density. Also, expand ***ply type*** and select ***Woven*** from the pull down menu.

Next step, we need to define the stress limits and Tsai-Wu constants for failure analysis. Expand ***Strength*** > (Drag) Orthotropic Stress Limits and Tsai-Wu Constants on to the new material. Enter the property values that are shown below:

13	Orthotropic Stress Limits		
14	Tensile X direction	1.02E+05	psi
15	Tensile Y direction	1.02E+05	psi
16	Tensile Z direction	50000	psi
17	Compressive X direction	-9E+05	psi
18	Compressive Y direction	-9E+05	psi
19	Compressive Z direction	-4.5E+05	psi
20	Shear XY	11327	psi
21	Shear YZ	11327	psi
22	Shear XZ	11327	psi
23	Tsai-Wu Constants		
24	Coupling Coefficient XY	-1	
25	Coupling Coefficient YZ	-1	
26	Coupling Coefficient XZ	-1	

5250 Core

Enter the properties for the 5250 Core as was done for the the weave. The values are displayed in the figure below:

1	Property	Value	Unit
2	Density	0.0524	lb in^-3
3	Orthotropic Elasticity		
4	Young's Modulus X direction	1.5E+07	psi
5	Young's Modulus Y direction	1.4E+06	psi
6	Young's Modulus Z direction	1.4E+06	psi
7	Poisson's Ratio XY	0.3	
8	Poisson's Ratio YZ	0.3	
9	Poisson's Ratio XZ	0.3	
10	Shear Modulus XY	8.3E+05	psi
11	Shear Modulus YZ	7.89E+05	psi
12	Shear Modulus XZ	56000	psi
13	Orthotropic Stress Limits		
14	Tensile X direction	3.582E+05	psi
15	Tensile Y direction	11000	psi
16	Tensile Z direction	11000	psi
17	Compressive X direction	-69500	psi
18	Compressive Y direction	-39000	psi
19	Compressive Z direction	-39000	psi
20	Shear XY	18800	psi
21	Shear YZ	18800	psi
22	Shear XZ	18800	psi
23	Tsai-Wu Constants		
24	Coupling Coefficient XY	-1	
25	Coupling Coefficient YZ	-1	
26	Coupling Coefficient XZ	-1	
27	Ply Type		
28	Type	Regular	

Steel for the Suspension Links

Suspension links are normal isotropic materials. It has purposely been made to be really stiff, so that the deformation of the monocoque can be seen more clearly. Here are the properties to use for structural steel:

1	Property	Value	Unit
2	Isotropic Elasticity		
3	Derive from	Young's Modulus and...	
4	Young's Modulus	1E+09	psi
5	Poisson's Ratio	0.01	
6	Bulk Modulus	2.3452E+12	Pa
7	Shear Modulus	4.9505E+08	psi

Go to Step 2: Geometry

Go to all ANSYS Learning Modules