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OPTIMIZATION OF ADAPTIVE WING SKIN COMPOSITE MATERIAL USING FEM

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Abstract: *The paper is presenting a finite element modeling of a plate, the purpose of the calculation being to define a composite material which can be used for skin at an adaptive wing, so can be obtain shape changing's: maximum displacement and minimum stresses. Use of software is essential in the evolution of engineering. In aviation products must provide performance and reliability at the highest level. Also, the use of software aims to reduce costs in design, implementation and operation.*
Keywords: *plate, skin, wing, model, displacement, stress.*

1. INTERNAL STRUCTURE OF THE WING

Modern design process is a complex process that involves: use modeling and analysis methods are based use of software tools. Finite element method provides solutions to problems in identifying the changes in stress fields and displacements mainly.
Composite materials have almost unlimited resistance to atmospheric agents action and environment process, amortization capacity for vibrations, great durability in application, lighter weight for composite materials over a metal structure, involving fuel economy, low costs.
The purpose of the calculation is to define a composite material which can be used for skin and to match with the needs for an adaptive wing, like changing shape: maximum displacement and minimum stresses.

2. GEOMETRIC MODELING / MESHING / MATERIALS OF THE PLATE

In the first step the geometry model of a plate with size 1000 x 500 mm is created in MSC Patran preprocessor. The geometric model is meshed with SHELL CQUAD (rectangle) elements type resulting a total elements number of 40 x 20 = 800 elements using IsoMesh method. The figure 1 and 2 are presented the elements of meshed plate:

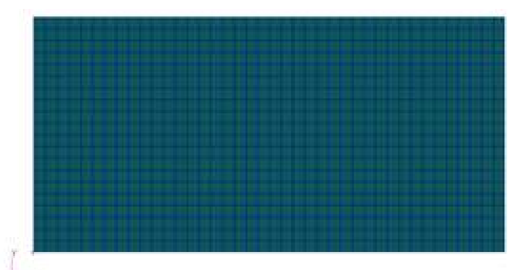


Figure 1: Geometry Model Meshed

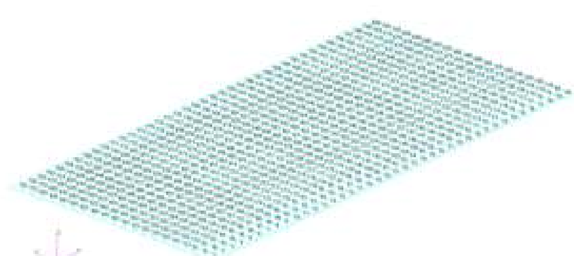


Figure 2: Model Elements

Finite element analysis to calculate the stiffness matrices requires knowledge of the physical parameters values. These properties can be grouped into geometric and material properties. In presented model orthotropic materials were defined in the preprocessor MSC Patran Materials menu [2]:

- TAPE – Pre-Impregnated unidirectional carbon fiber material;

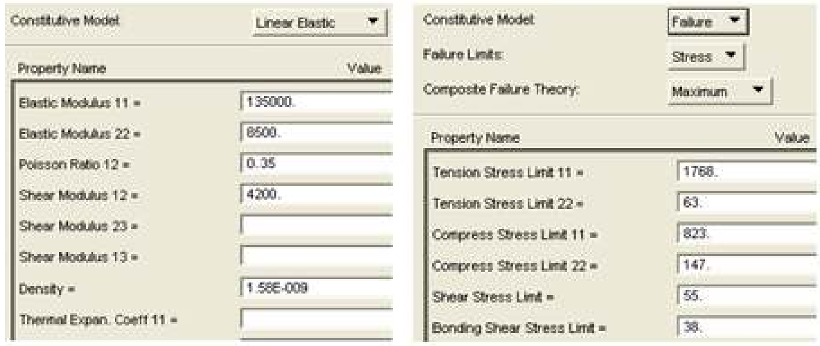


Figure 3: Mechanical characteristics of the TAPE material

- FABRIC- Pre-Impregnated bidirectional carbon fiber material;

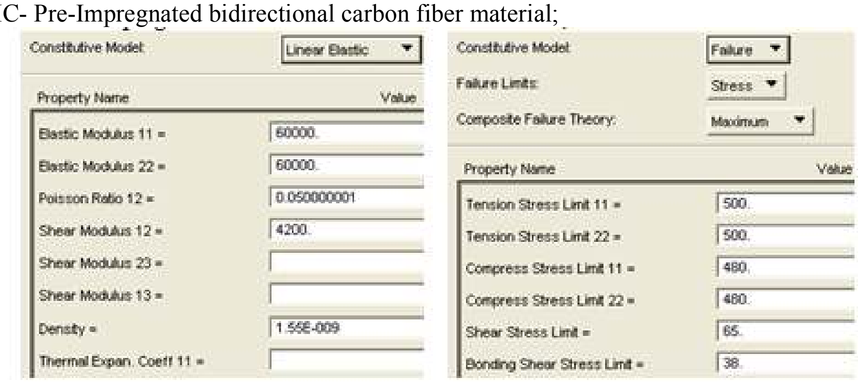


Figure 4: Mechanical characteristics of the FABRIC material

3. BOUNDARY CONDITIONS: CONSTRAINTS AND LOADS

The plate is considered fixed in one end, here must by blocked the movements of the X, Y, Z axes and rotations on the X, Y axes. In the other end the plate is supported, there are blocked movements on axes Y, Z and rotations on the X, Y [1].

A force of 1000 N is distributed uniformly with a MPC (Multi Point Constraint s) factor, RBE2 type (Rigid Body Element) on the median transverse axis of plate.

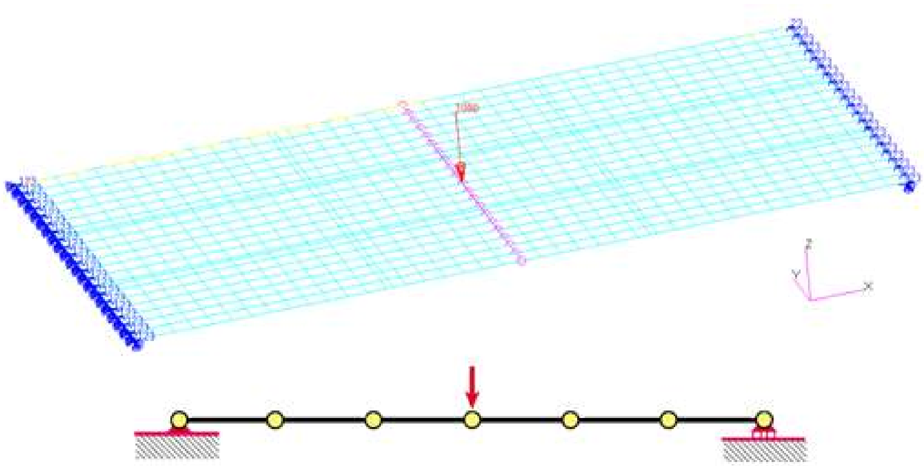


Figure 5: Applied forces and fixation

4. COMPOSITE LAMINATE DEFINITION:

MSC Laminate Modeler, module of MSC Patran is used to define laminate composite.
Composite material is created based on previously defined orthotropic materials. Material characteristics were introduced in LM_Materials menu: composite material name, select type of composite material: Drape, the material is chosen from the list of materials orthotropic defined above, insert layer thickness 0.25mm.
Composite material layers are created by using LM_Ply menu: name of the ply, choose the type: Drape, composite material is select, the surface, application direction, the point for the surface normal direction, the reference direction of fiber inclination, reference angle to the direction of the laminate ply is applied. Are defined three layers as: bidirectional fiber at 45°, bidirectional fiber at 0° and unidirectional fiber at 0°.
LM_Layup menu is used to define the order previously layup definition for composite. Automatically are created groups, materials and properties:

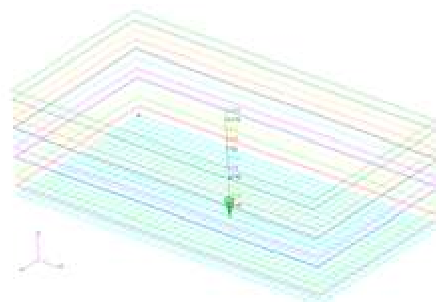


Figure 6: 3D viewing of the Plays which defines the Layup

The procedure is repeating to create 50 layups which results by combining the struts.

5. MODEL ANALYSIS / ACCESSING RESULTS

The job to be analyzed is defined in the preprocessor MSC Patran Analysis menu. Is set an linear static analysis type. MSC Nastran processor is running the model with a verification method for checking errors in preprocessing. Results are accessed with post-processor MSC Patran and displays using the Results menu. The maximum deformation and maximum von Mises stress for the 50 layups previously created are checked.

6. FINITE ELEMENT ANALYSIS RESULS

The purpose of the calculation is to define a layup to match the needs of an adaptive wing, which can change its shape: maximum displacement and minimum stresses. Therefore in next step will be calculated the report Δ/σ of stress and tension obtained for the 50 layups.
The table 1 will present top three most effective cases, selections based on maximum report of displacement and stress:

Table 1: Report Δ/σ (top three most effective cases)

	σ	Δ	Δ/σ
Layup15	423	739	1.747
Layup29	422	737	1.746
Layup11	455	791	1.738

For 15th Layup calculation the next result where obtained:
Maximum stress: σ_{15}= 423 [MPa].
Maximum displacement on Z direction: Δ_{15} = 739 [mm].
Rapport displacement /stress: Δ_{15}/σ_{15} = 1.747.
The order of laminate is presented in table 2 and figure 7.

Table 2: Layers succession in 15th laminate

	1	2	3	4	5	6	7	8	9	10	11
Layup15	F45	F45	F45	F45	T0	F45	T0	F45	F45	F45	F45

Figure 7: Layers succession in 15th laminate

7. DISPLACEMENT /STRESSES

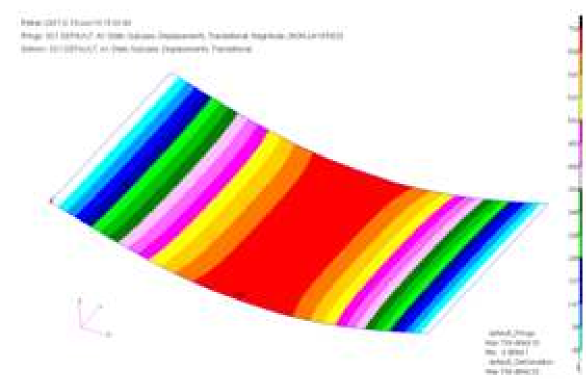


Figure 8: Displacement of the plate

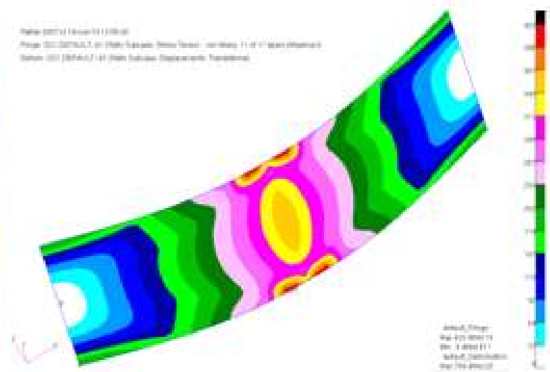
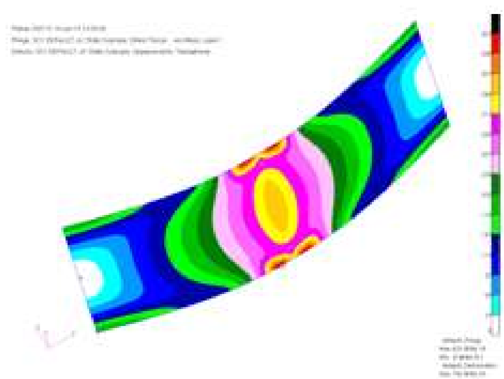


Figure 9: Equivalent Von Misses stresses (at deformed plate)

In figures 8 and 9 are presented equivalent Von Misses stresses (at deformed plate), the maximum values is 423 MPa and the displacement of the plate with a maximum of 739 [mm].
In next figures are presented Von Misses stresses (at deformed plate) for each layer, to see how behaves and how the stresses are distribute, according to the elements orientation:



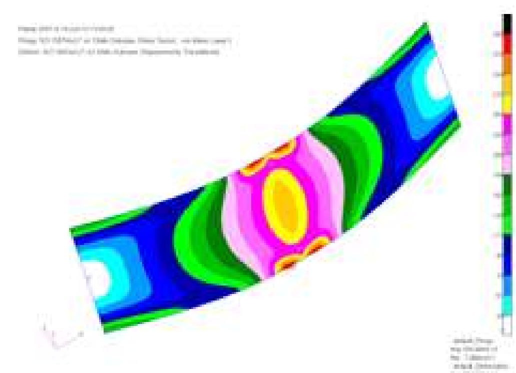


Figure 10: Von Misses stresses on each ply at 15th layup

Table 3: Von Misses stresses on each layer at 15th layup

	1	2	3	4	5	6	7	8	9	10	11
Layup15	F45	F45	F45	F45	T0	F45	T0	F45	F45	F45	F45
$\sigma_{von\ Misses}$	423	228	253	169	296	6	296	169	253	338	423

Analyzing Table 3, it can be notice a change in maximum stress between 6 [MPa] and 423 [MPa], the following distribution: minimum stress is found on layer number 6, it is on neutral fiber of layup, making the transition between two symmetrical parts. It can be observed a symmetrical variation reported to neutral fiber and the maximum stress of 423 MPa can be find on layers 1 and 11.

8. CONCLUSION

The presented method, using a FEM program, gives a general overview in order to understand that by using specific software for the engineering field helps significantly to achieving the goals of producers, improving the supply of new technologies to create both real and virtual product; development of the existing transport safer at this point (air). Use of software is essential in the evolution of engineering.

The aircraft industry must offer performance and trust at the highest level for aircraft structures, this is the reason for use composite materials on a greater percentage of aircraft components. The use of software aims to reduce costs in design, achievement and development. This is the reason why a theoretical analysis of finite elements is very useful previous to tests on samples.

A symmetric composite material is more durable then a nonsymmetrical one. The angle of the ply also has a great impact on material durability.

Composite materials are used increasingly more in commercial industry and in military technique. They have improved characteristics, epoxy resins or polyester, polyurethanes and vinyl polymers reinforced with carbon fibers, aramides or boric possess a high level of resistance and mass rigidity, high stability and corrosion resistance, low thermal conductivity and high resistance to repeated deformations.

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