FEM Modeling of a 3D Carbon Fiber Pylon

I. López G., B. Chiné, J. León S.

Costa Rica Institute of Technology, School of Materials Science and Engineering, Cartago, Costa Rica

Introduction:

The manufacturing of fiber reinforced polymers (FRP) by 3D printing technologies allows to improve the mechanical properties of materials used in additive manufacturing technologies. In this work we carry out an experimental method to evaluate the compression properties of 3D printed carbon reinforced parts and develop a computational model of a printed Pylon prototype.

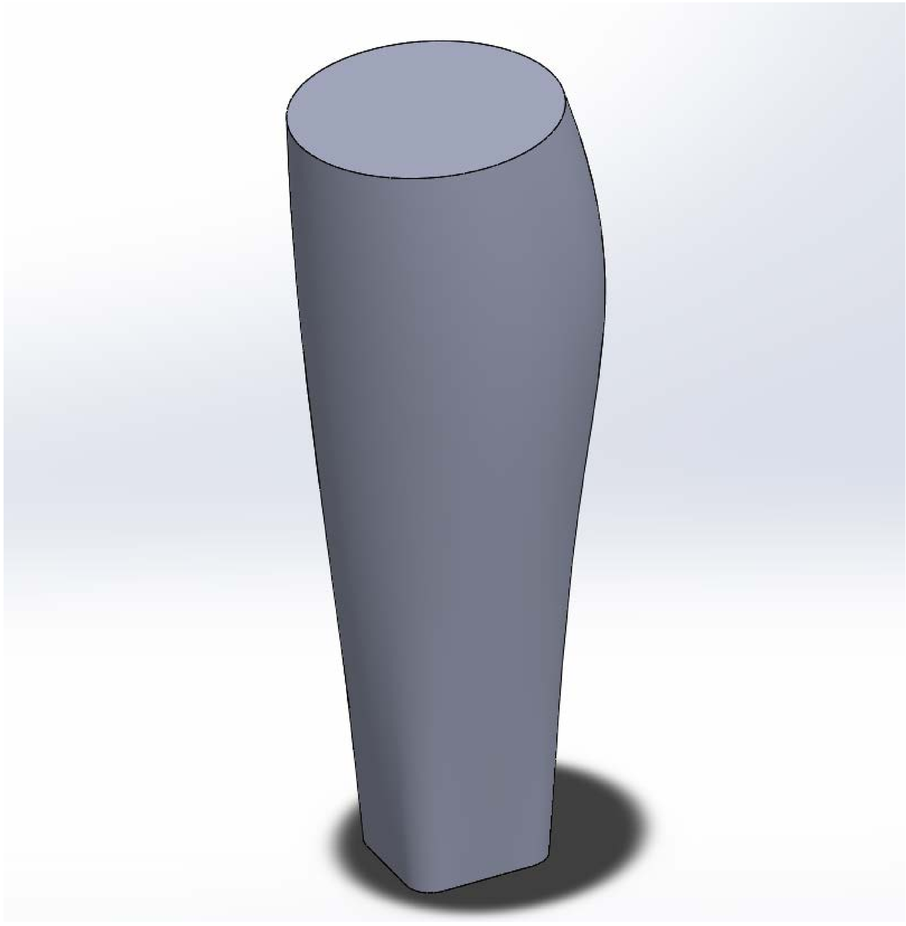

Figure 1. Pylon prosthetic prototype.

Computational Methods:

In COMSOL Multiphysics®, we use the E_z and E_y modulus of the material obtained previously from a compression test and estimate the Possion ratio under linear strain. Computational simulations are developed by applying a force equal to the experimental load in correspondence of the yield point of the material, registered during the mechanical test. In our modeling work, three different materials are evaluated. The first model considers an isotropic material, the second one analyzes a reinforced laminated material, while the third model studies an orthotropic solid material.

Results:

For the isotropic model simulation we use a Poisson ratio of 0.025, in order to approximate better the experimental results. Fig. 2 depicts the results obtained. By using the orthotropic model, the computations give an error of 16.4%, which we assume as acceptable for 3D printed reinforced materials. Using the former computational model we simulate a heel strike, obtaining a stress greater than the yield value (Fig.4), requiring a redesign of this part.

Table 1. FEM results of the isotropic model.

FEM [MPa]	Yield [MPa]	Error
44.3	42.97	3.09%

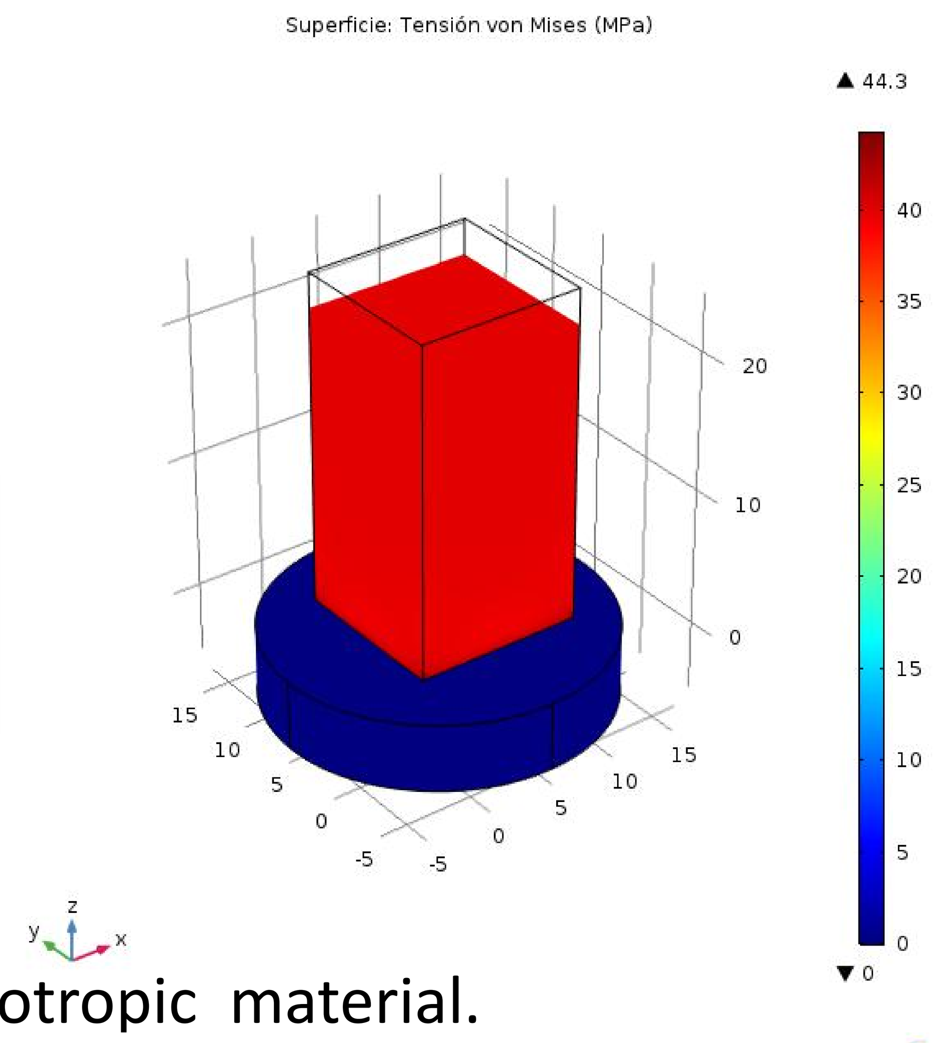

Figure 2. Simulation of the isotropic material.

Table 2. FEM results for the orthotropic model.

FEM [MPa]	Yield [MPa]	Error
50	42.97	16.4%

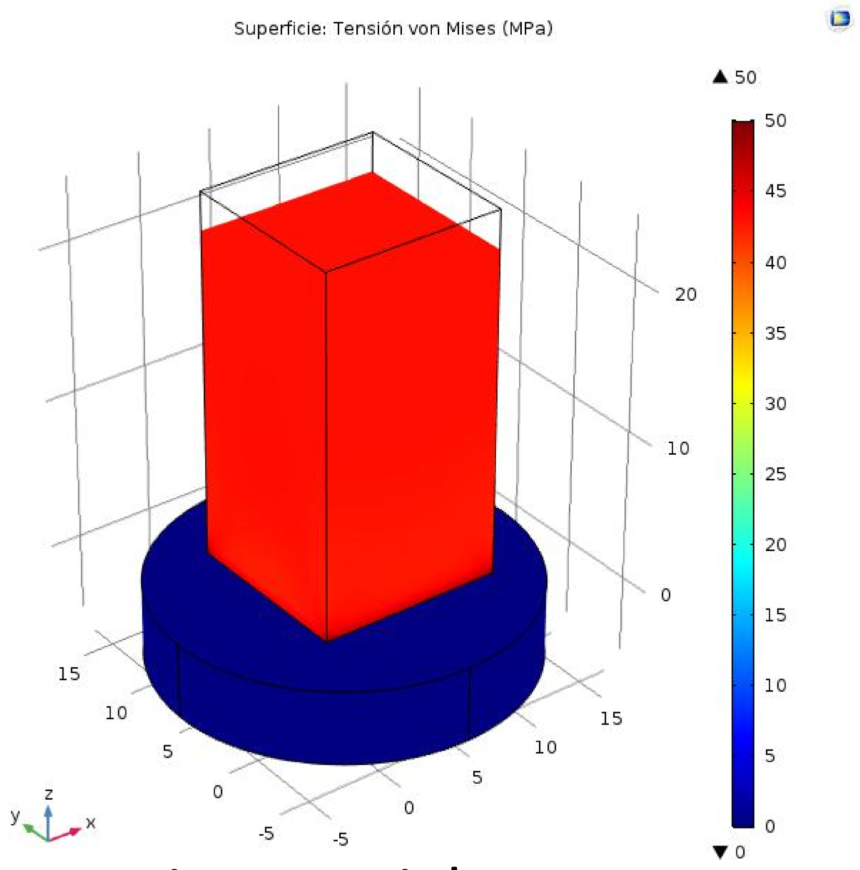

Figure 3. Simulation of the orthotropic material.

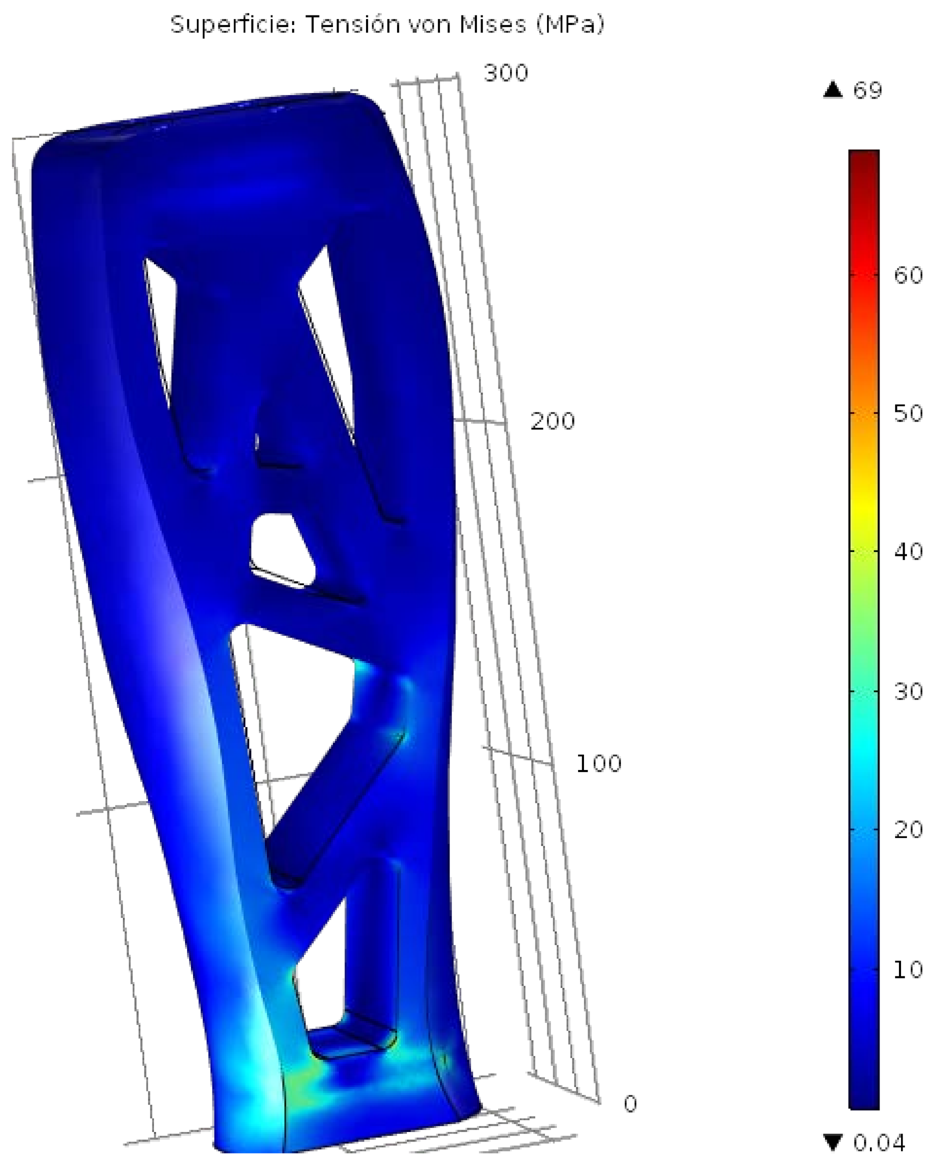

Figure 4. FEM results of a prototype pylon.

Conclusions: A modeling work of 3D printed carbon reinforced parts has been developed. Isotropic and orthotropic materials have been considered in order to approximate the mechanical behavior of 3D printed FRP components.

References:

Domingo-Espin, M. Poigoriol-Forcada, J. M. & Garcia-Granada, A. A. Mechanical property characterization and simulation of fused deposition modeling Polycarbonate parts. *Materials & Design*, **83**, 670-677. (2015).

Sutradhar, A. Park, J. Carrau, D. & Miller, M. Experimental Validation of 3D Printed Patient-Specific Implants using Digital Imagen Correlation and Finite Element Analysis. *Computers in Biology and Medicine* **52**, 8-17. (2014).