MECHANICAL CHARACTERIZATION AND COMPARISON OF HYPERELASTIC ADHESIVES. MODELLING AND EXPERIMENTAL VALIDATION

F.J. Simón[1], O. Cuadrado[1], E.A.S. Marques[2], M. Sánchez[1], L.F.M. da Silva[3]
[1]Department of Mechanical Engineering and Energy University Miguel Hernández, Elche, Spain.
[2]Institute of Science and Innovation in Mechanical and Industrial Engineering (INEGI), Porto, Portugal.
[3]Department of Mechanical Engineering, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias 4200-465 Porto, Portugal.

INTRODUCTION AND OBJECTIVES

The use of highly flexible structural adhesives is becoming more and more common in commercial vehicle applications (fig1), due to the advantages they offer over other types of bonding. On the one hand, they are compatible with the large bending and torsional deformations that occur in the bodies of large vehicles, maintaining their structural integrity and strength, and on the other hand, they act as sealants absorbing small dimensional differences due to manufacturing tolerances. The main objective of this work is to characterize the hyperelastic behaviour of high flexibility adhesives, for their subsequent numerical modeling by means of finite element programs. This will allow to obtain more optimized and structurally efficient designs, and on the other hand, to reduce the time and cost of the project, by reducing the number of prototypes to be manufactured and tested until the final design is reached.

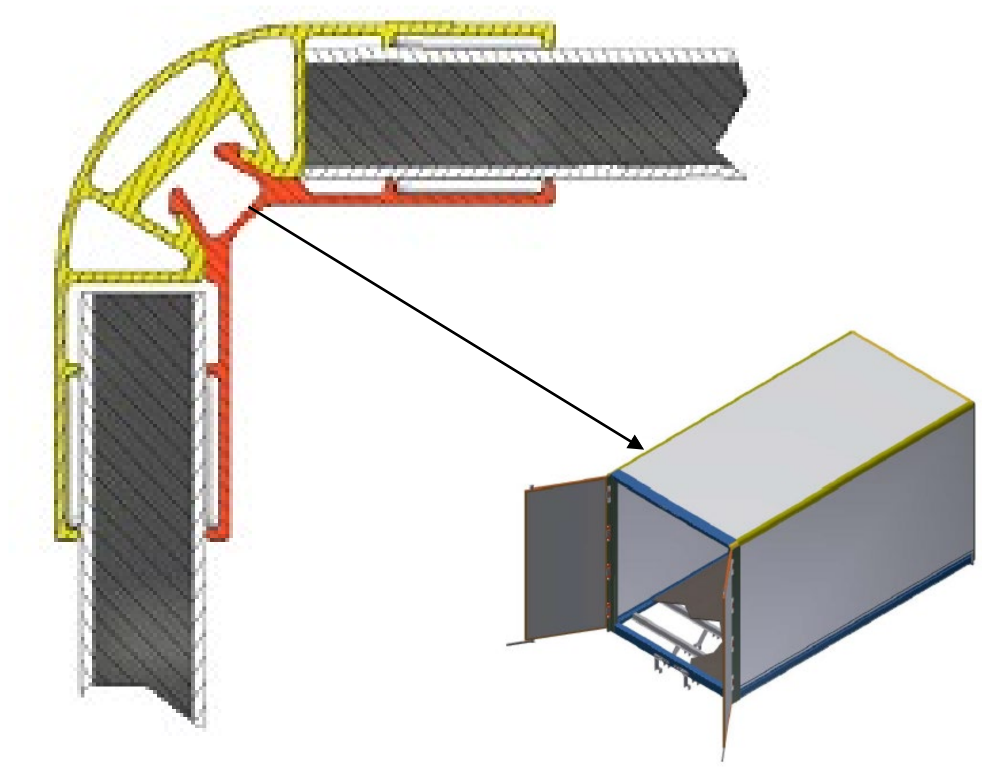
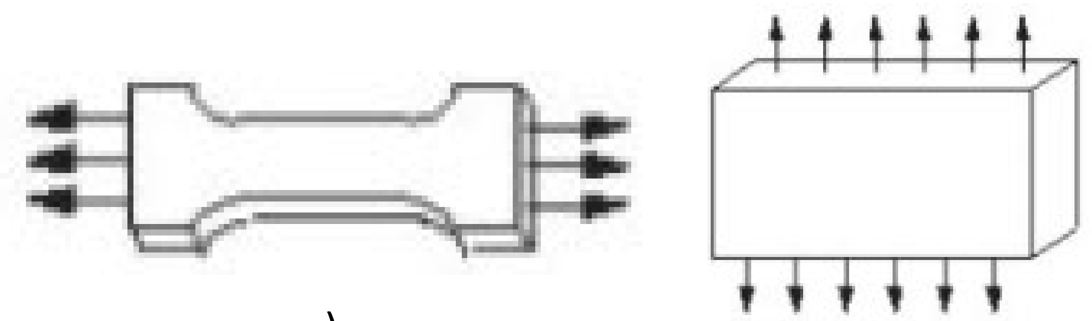


Figure 1. Sandwich panel bodywork with adhesive joints.

METHODOLOGY AND HYPERELASTIC MODEL FITTING



a) b)

Figure 2. a) Uniaxial tensión. b) Planar tension.

In order to reproduce the behaviour of the flexible adhesive, different models of those commonly used for hyperelastic materials have been tested. For this, it has been necessary to design and manufacture specimens of different geometries, appropriate for obtaining the hyperelastic constants of the material models. Tests were carried out with cured adhesive specimens, subjected to uniaxial tension (fig 2.a) and pure shear (fig 2.b). The adhesive used for this research was a monocomponent polyurethane (PUR).

From the data measured in the tests, stress-strain curves of the material are obtained (fig 3-4). With the help of a finite element program, and taking these curves as a target, the constants of different hyperelastic models can be adjusted. In this study, the following have been considered: Mooney-Rivlin, Neo-Hookean, Ogden (N = 1 and N = 2), Polynomial (N = 2). Finally, the model with the best fit to the experimental results was selected. And once the hyperelastic model has been adjusted and selected, it can be used to simulate the behaviour of different joints.

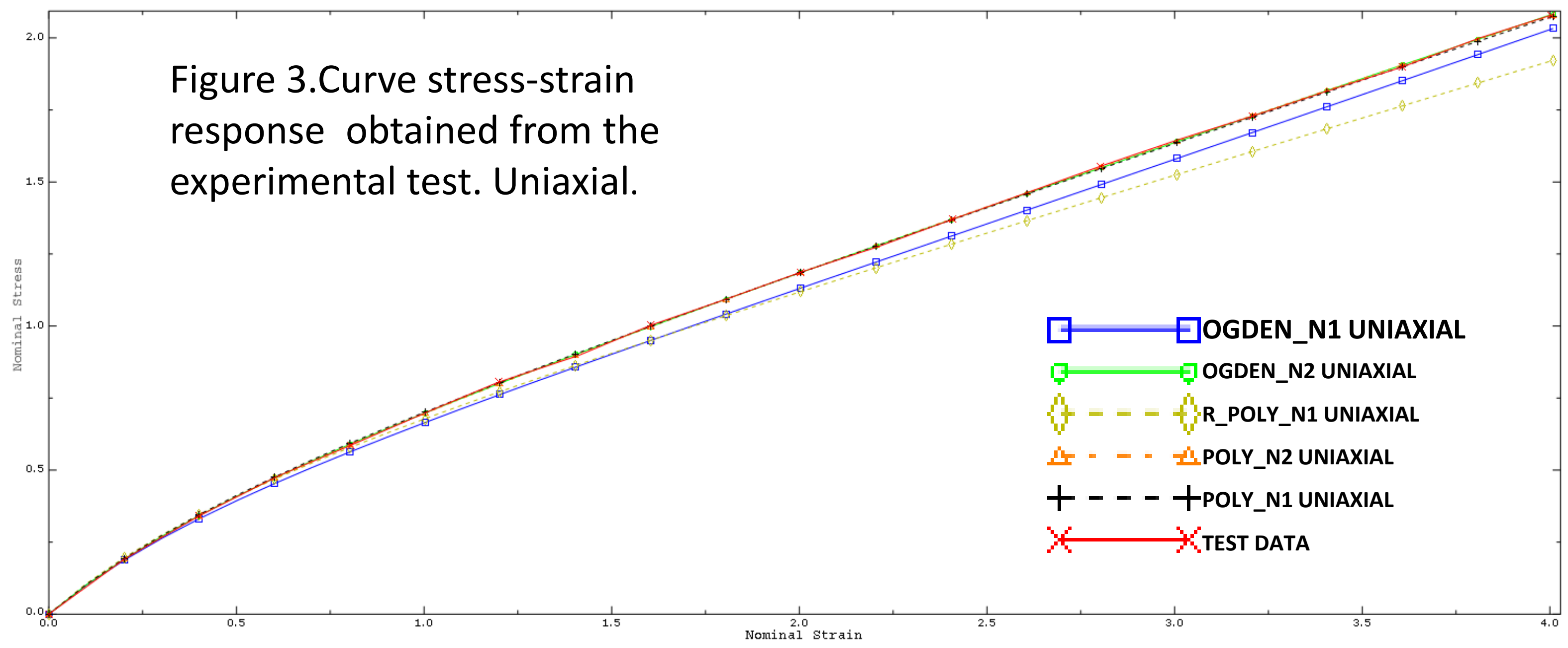


Figure 3.Curve stress-strain response obtained from the experimental test. Uniaxial.

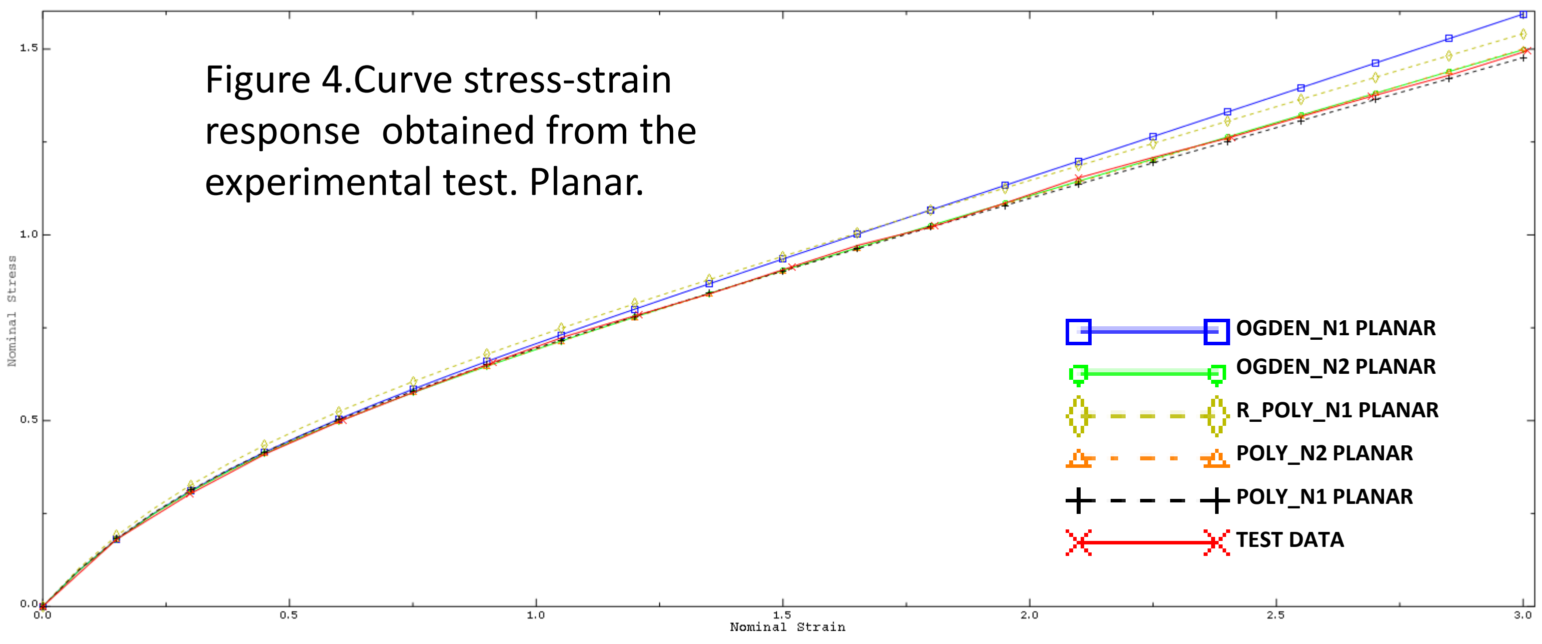


Figure 4.Curve stress-strain response obtained from the experimental test. Planar.

EXPERIMENTAL VALIDATION

To validate the selected hyperelastic model and the set of adjusted parameters, SLJ adhesive bond specimens (fig 5), with adhesive thicknesses of 1 and 3 mm working in shear, have been used in the modeling of adhesive bond specimens. The results obtained in force and displacement have been compared with those measured in tests on real specimens (fig 6), verifying the good correlation between them (fig 7).

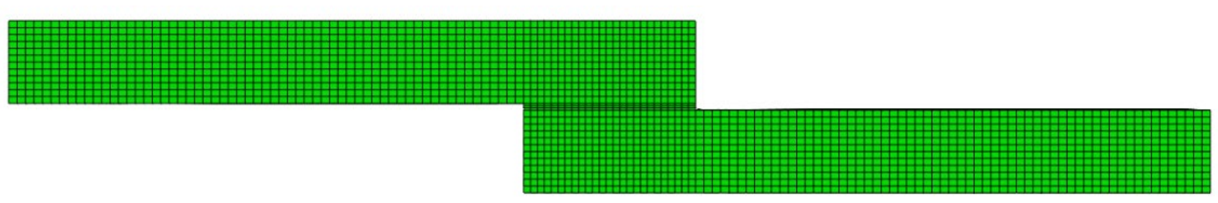


Figure 5. FE simulation SLJ.

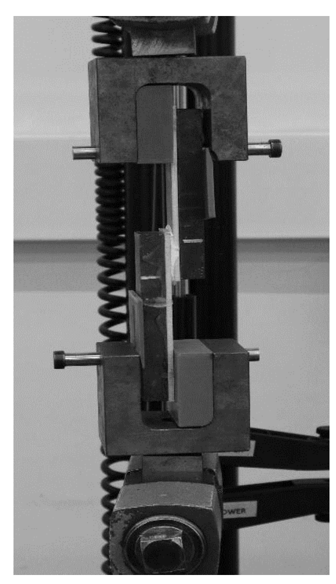


Figure 6. SLJ test on test bench.

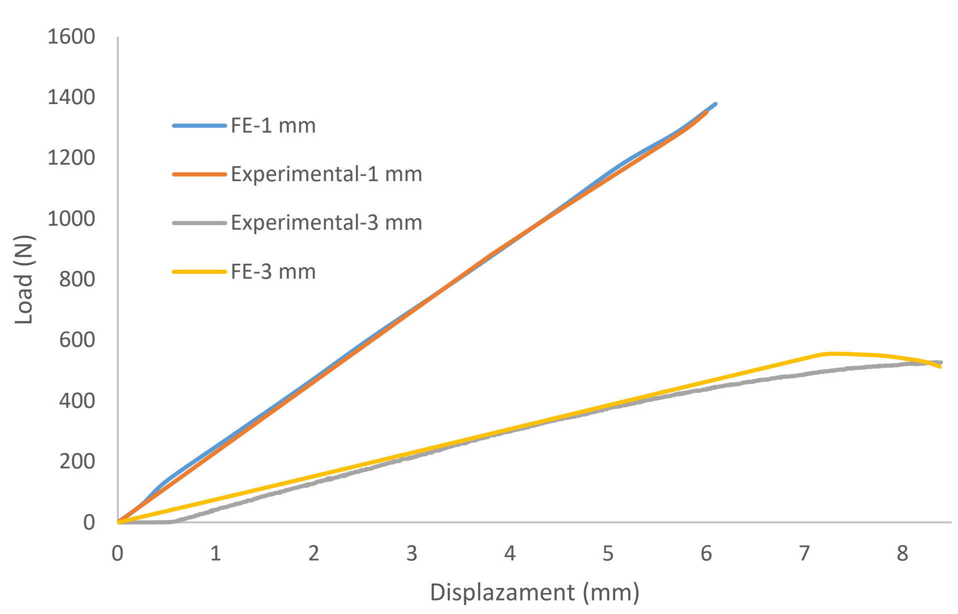


Figure 7. FEM-experimental validation.