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On the design of a heterogeneous mechanical test using a nonlinear topology optimization approach

M. Gonçalves[1, a *] and A. Andrade-Campos[1, b]

[1]Department of Mechanical Engineering, Centre for Mechanical Technology and Automation, University of Aveiro, Portugal

[a]mafalda.goncalves@ua.pt; [b]gilac@ua.pt

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Background

Numerical simulation is nowadays increasingly used to avoid the costs and time associated with experimental testing. However, the accuracy of the numerical results is still an issue. Material behavior and characteristics are required by the software, and these are usually obtained by performing a considerable number of classical mechanical tests. To improve this procedure, heterogeneous tests have been used instead. More and richer information can be obtained with a single test due to the heterogeneous displacement and strain fields that are induced. This work aims to design an optimal heterogenous mechanical test to enhance the material mechanical characterization process.

Procedure

A topology-based optimization methodology [1] is implemented with the aim of finding the best material layout in the sheet specimen. Highly heterogeneous displacement fields are induced by applying an adapted version of the theory of compliant mechanisms. To account for the large-displacements that the specimen is undergoing, a geometrically nonlinear finite element analysis is proposed [2]. Therefore, the design optimization problem aims to maximize the output displacement under a given material volume constraint and considering the system equilibrium, and, consequently, creating diverse strain states. The performance of the obtained solutions is then evaluated taking into account the heterogeneity of stress states using a mechanical indicator [1].

Key findings

The results are not available yet, however, it is expected to obtain:

- An optimal mechanical test designed using a nonlinear topology-based methodology.
- Heterogeneous stress states induced on the specimen, providing high diversity of information about the material behavior.
- A sheet specimen that can be tested using Universal Testing Machines due to the tensile boundary conditions that are applied.

References

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