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Topology Optimization (TO) is a powerful tool for the optimization of product geometry and weight for compliance with structural requirements. The shapes generated by TO are generally complex and intricated, but nowadays they can be produced by Additive Manufacturing (AM) or 3D Printing [1]. 3D Printing is the term that is widely used to address layered manufacturing in the case of consumer applications with polymeric materials [2] while AM mostly refers to industrial applications. The basic algorithm for TO is based on the Solid Isotropic Material with Penalisation (SIMP) method [3].

The increasing importance of AM has recently driven researchers to develop modified versions of the SIMP algorithm [4] for considering the constraints and peculiarities of layered manufacturing, such as the use of lattice structures with intermediate densities [5] or the need to include support structures in the case of overhanging features [6]. Owing to the diffusion of AM and 3D Printing, SIMP methods have also been implemented in many commercial computer aided design and engineering (CAD/CAE) software packages. Specific TO software is also available outside CAD packages. However, the anisotropic nature of layered technologies brings additional challenges for TO methods, especially in the case of load bearing structures [7]. There is the need of improving the performances and the accuracy of TO by considering the peculiarities of the adopted AM techniques and the properties of the specific material.

In this work a commercial TO software, SolidThinking Inspire, is used to optimize the geometry of polymeric beams subjected to a three-point bending test under different loading levels. Two different AM technologies are considered to produce the beams: powder bed Selective Laser Sintering (SLS) and material extrusion 3D Printing. Several polymeric materials are used and for the specific AM process the TO calculations are defined by considering the mechanical properties declared by the supplier on the material datasheet. The results of TO are then validated by fabricating and testing replicas of the optimized beams with the corresponding material and process.

The workflow of the research is represented in Figure 1. Starting from the CAD model of a three-point bending beam with some design space for TO (Fig. 2a), the TO is then executed (Fig. 2b) with different load levels for the different materials and the optimized beam is then fabricated using the corresponding AM process (Fig. 2c). Finally, the results of the 3-point bending test performed on the replicas of the optimized beams are compared to the TO results. Correlation and differences between the experimental behaviour of the beam and the flexural resistance predicted by TO are analysed and discussed.

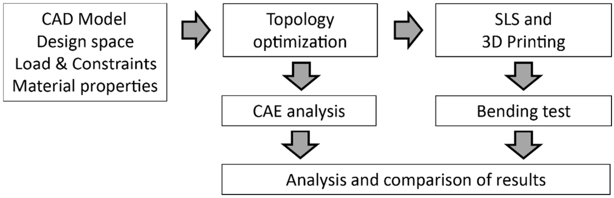

Figure 1. Workflow for experimental validation of TO results.

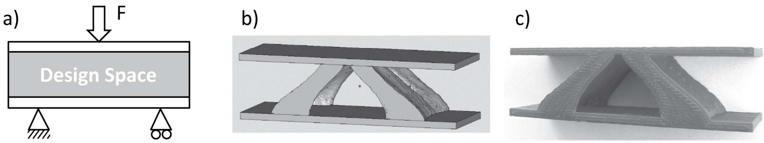

Figure 2. Model for TO of beams subjected to three-point bending test (a), optimized beam with a 70% weight reduction (b), 3D printed optimized beam in ABS for experimental testing (c).

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