MECHANICAL CHARACTERIZATION OF SLA 3D-PRINTED PARTS

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1. Introduction

Stereolithography is becoming a more and more popular 3D-printing technology, as it offers superior dimensional accuracy and overall part quality when compared to the cheaper and more widespread Fused Deposition Modeling. [1] The price of stereolithography (SLA) printers is nowadays affordable when compared to several other technologies on the market. Originally, SLA was used only for concept models or ornamental purposes, however, improvement in material properties encourages several makers and engineers to apply this technology also in load-bearing applications. For this purpose, it is vital to know the mechanical characteristics of the materials used. In this work, tensile tests on SLA 3D-printed clear resin samples are performed and results are compared with the manufacturer's datasheet.

2. Materials and methods

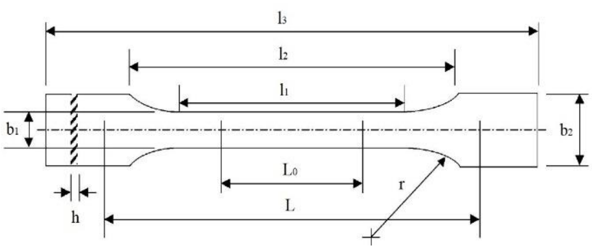

Fig. 1. Geometry of the 1BA specimens used.

Tensile tests were performed following ISO 527-1 norm [3]. The specimens adopted are of type 1BA: Figure 1 shows the geometry of the samples. Specimens were 3D-printed in a Formlabs™ Form 2™ SLA machine, using Clear V4™ resin. Layer height was set to 50 μm. Specimens were printed at different orientations, with θ varying from 0° to 90° at 15° intervals, where θ is defined as the angle between the specimen's axis and the vertical direction (z axis), as shown in Figure 2. Three samples were printed for each orientation.

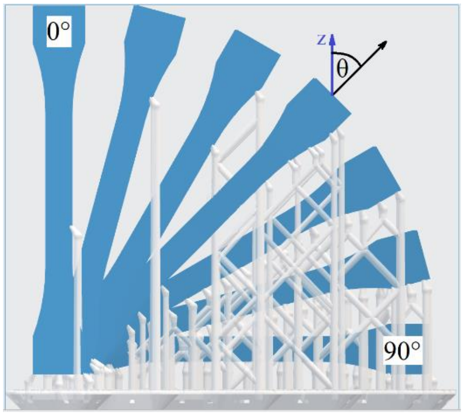

Fig. 2. Different printing angles.

The in-house-designed tensile machine adopted for these tests consists of two caps, which are mounted on the opposite ends of a stiff cylindrical frame. On the lower end, a grip is mounted on a platform. A load cell is positioned on the support connecting the platform to the frame. The upper cap hosts the hand-driven screw mechanism through which the displacement is applied. An extensometer measures the distance between the cap and the grip. **Chyba! Nenalezen zdroj odkazů.** shows a CAD drawing of the system.

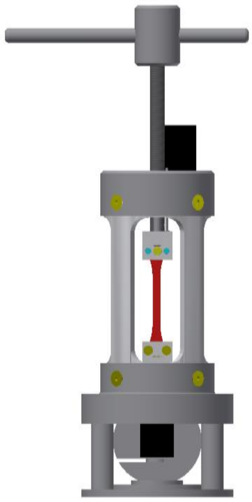

Fig. 3. CAD drawing of the tensile testing machine.

3. Results and discussion

Stress-Strain curves were obtained for each specimen and are reported in Figure 4.

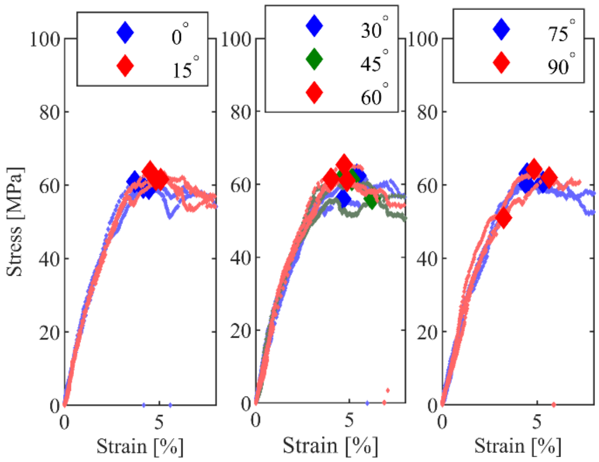

Fig. 4. Stress-Strain curves for the 21 tested specimens.

Maximum stress and Young's modulus were calculated for each sample. The mean value for each angle is plotted in Figure 5.

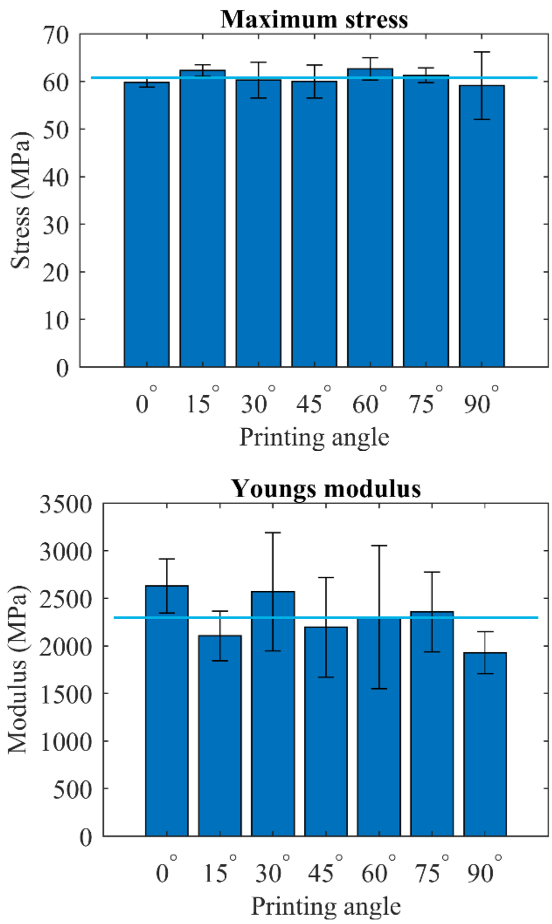

Fig. 5. Mean characteristics per printing angle θ.

Overall statistics for the material properties are summarized in Table 1. These are compared to the technical datasheet provided by the manufacturer [4].

The results obtained in-house show, on average, a slightly lower maximum stress than the manufacturer's datasheet, while the Young's modulus is very similar. This study confirms the Formlabs™ statement that SLA 3D-printed parts are isotropic: in fact, there is no evident relationship between printing orientation and mechanical characteristics, as shown in Fig. 4 and 5.

Table 1. Isotropic behavior material characteristics.

		Max stress [MPa]	**Strain at max stress [%]**	**Young's modulus [MPa]**
In-house test	**Mean** (Std.)	**60.8** (1.33)	**4.75** (0.42)	**2298** (249)
Formlabs™ datasheet	**Mean**	**67.1**	**-**	**2388**

4. Future developments

The final goal of this work is the experimental validations of numerical simulations, i.e. of the mechanical properties of bone structure and for the topological optimization of load-bearing parts, Fig. 6. To this aim, the mechanical characterization of Clear V4™ resin will be completed by compression tests.

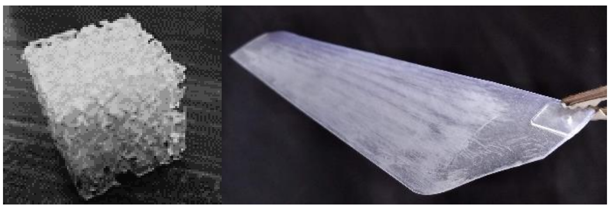

Fig. 6. Examples of SLA load-bearing applications: internal bone structure (left); model helicopter replacement blade (right).

References

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