PolyJet Digital Materials Tensile Characterisation based on ASTM D412

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Introduction

The purpose of this report is to present the procedure and results of a material tensile testing experiment conducted on Stratasys PolyJet Vero-Agilus30 composite materials (from Shore A-30 to Shore A-95). The procedure is based on the ASTM D412 international standard for tensile testing elastomers. The equipment used for tensile testing is an Instron 34SC-5 universal testing machine. These results are presented to the research community to be re-used in the creation of, e.g., materials models for soft robots.

Experimental Procedure

1. Stratasys PolyJet Vero-Agilus30 composite specimens were 3D printed using a Stratasys Connex3 Objet500 PolyJet printer (last calibrated on 13th February 2023).
   (a) The specimens were 3D printed in the shape of ASTM D412 dogbone C standard with dimensions shown in Fig.1.
   (b) The dogbone models were orientated flat on the build tray, horizontally along the x-axis.
   (c) Specimens of hardness Shore A-30, Shore A-40, Shore A-50, Shore A-60, Shore A-70, Shore A-85, and Shore A-95 were produced using the printer's predefined blends of Agilus30 Black and VeroClear material. For each Shore A type, 5 specimens were produced.
   (d) All specimens were printed on heavy support using SUP706 material and VeroClear.
   (e) Matte option was selected as the finish.
   (f) The specimens were allowed to rest on the print bed for an hour after the print was completed. They were then subsequently removed carefully using a scraper.
   (g) The specimens were cleaned and supports were removed using a waterjet machine. They were then allowed to dry at room temperature (20-25°C) for 3 hours before tensile testing was performed.

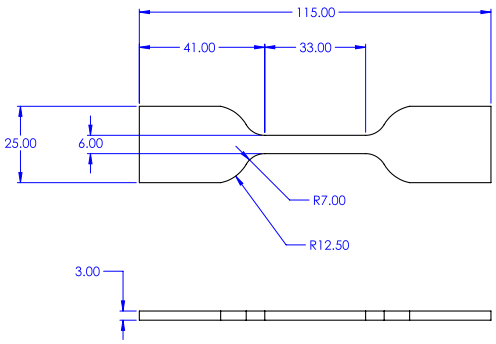
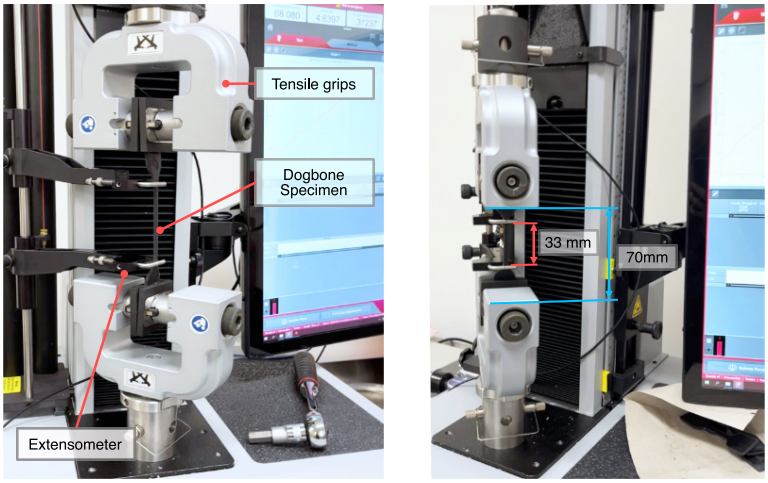


Figure 1: Dimensions of dogbone (type ASTM D412 C) specimen in mm.



(a) (b)

Figure 2: Tensile characterisation test setup.

2. The tensile chracterisation setup is shown in Fig.2. The Instron 34SC-5 universal testing machine was set up with a 500N Static Load Cell (2519 Series S-Beam) and a pair of screw side action tensile grips. Pre-configured ASTM D412 Test Method A from Bluehill Universal was selected on the the Instron.
   (a) The specimens were then placed between the grip jaws of the Instron. The gap between the top and bottom surface of the grips was 70mm.
   (b) The Instron's long travel XL extensometer was used to measure elongation of the specimens. The extensometer clips were placed 33mm apart on the middle section of the dogbone specimen.
   (c) Each specimen was stretched at a rate of 500 $\pm$ 50mm/min.
   (d) The force applied and the elongation of the specimens were continuously recorded throughout the test until break at a sampling rate of 100 Hz.
   (e) These steps were repeated for the remaining four specimens.
3. Data analysis of the results were done using MATLAB R2022 software.
   (a) Tensile strength and elogation at break was obtained directly from the stress-strain results.
   (b) The Young Modulus was calculated through linear fitting the gradient of the stress-strain curve before yield point.

Results

The reported values for Young's Modulus, tensile strength, and percentage elongation at break were obtained by taking the average of five specimens and calculating their standard deviations.

Material		Young's Modulus (MPa)	Tensile Strength (MPa)	Elongation at Break (%)
Shore A 30	Mean	0.46	1.42	304
(Agilus30)	S.D.	0.05	0.06	18.8
Shore A 40	Mean	0.50	1.30	253
	S.D.	0.03	0.11	6.5
Shore A 50	Mean	0.60	1.44	230
	S.D.	0.05	0.11	3.6
Shore A 60	Mean	0.90	2.37	247
	S.D.	0.05	0.05	10.4
Shore A 70	Mean	1.39	2.88	200
	S.D.	0.08	0.13	12.7
Shore A 85	Mean	11.51	4.78	104
	S.D.	1.75	0.29	9.4
Shore A 95	Mean	39.98	9.76	86
	S.D.	2.70	0.59	5.3