Elastic characterization of a material

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Updated:
October 3, 2022

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1 Material: Dedmas Elite Black 40

Figure 1: Pictures of the tested material: Dedmas Elite Black 40. On the left hand side: the two sheets received. On the right hand side: two of the sample beams extracted from the sheets (with lengths bigger than the 70-mm long cantilevers that will be tested). The sheets have been provided as a layer of material (in black), and include an adhesive layer with a translucide protective film.

The mass density of the material has been measured to 1 677 ± 8 kg.m^{-3}.
The thickness of the material has been measured to 2.4 ± 0.1 mm.

The method used to characterise the [visco-]elastic parameters of the material is described in appendix C).

Four beams, from which cantilevers of 70 mm in length have been obtained, were extracted from the sheets (two beams per sheet). The material has been tested without support metal beams, with or without removing the translucide protective film[1].

[1] Thus we have checked that the protective film has no noticeable impact on the beam behaviour.

The figure 2 shows an example of the Frequency Response Function (FRF), defined as the ratio of the velocities between the free tip of the cantilever beam and its other tip excited with a controlled transverse displacement[2]. From the observation of the curve, the three first bending modes are clearly identified.

[2] Two points with low signal to noise ratios, around 150 and 250 Hz, are disregarded during the characterization process. The origins of these low signal to noise ratios are not clearly identified. They can occur from an unrelated vibration during the measurements or a minor defect in the beam for example.

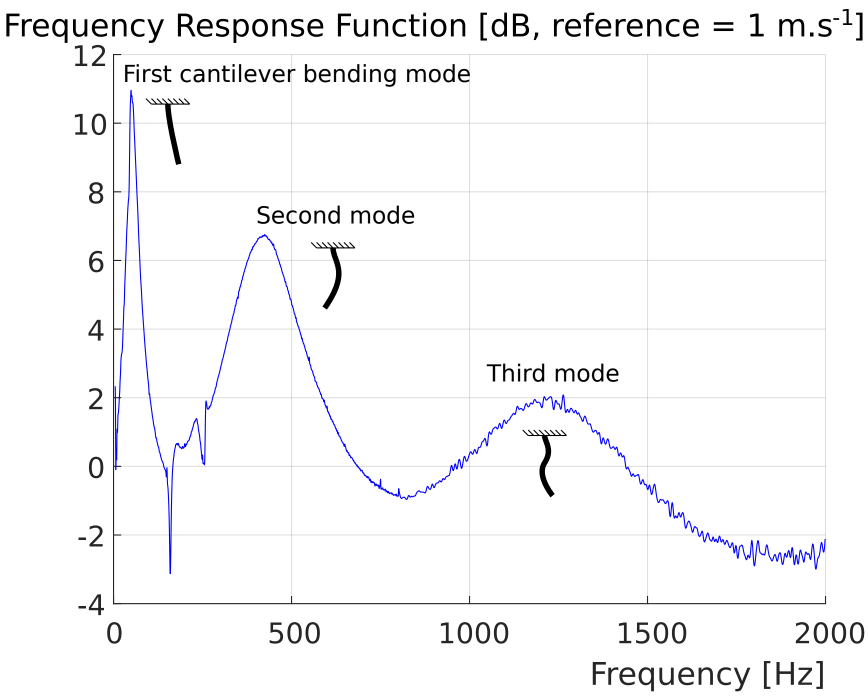

Figure 2: Example of a Frequency Response Function (FRF), defined as the ratio of the velocities between the free tip of the cantilever beam and its driven tip, for one beam of length 70 mm.

The FRF values below 0 indicate that the free tip of the beam has a velocity (and a displacement) smaller than its excited tip. This is commonly observed and predicted for highly damping materials.

Using the expressions reported in ISO 6721-3[3] or ASTM E756[4], the elastic parameters are estimated at the frequencies corresponding to all identified modes (see table 1 and figure 3).

[3] ISO 6721-3. Plastics - determination of dynamic mechanical properties of plastics - flexural vibrations - resonance-curve method. *International Standard Organisation*, 1996.

[4] ASTM E756-98. Standard test method for measuring vibration-damping properties of materials. *American Society for Testing and Materials*, 1998.

Frequency [Hz]	**E** (σ_X) $\times 10^6$ N.m^{-2}	η (σ_X) -
48	627 (53)	0.49 (0.02)
432	1 311 (48)	0.44 (0.02)
1 216	1 479 (39)	0.40 (0.01)

Conditions:
Temperature: 21.0 °C
Ambient Pressure: 99 700 Pa
Relative humidity : 62%

Table 1: **Material: Dedmas Elite Black 40**: Mean values of the Young's modulus (E) and corresponding loss factor (η) of the tested material samples assumed to be homogeneous. σ_X represents the standard deviation over the four tested samples.

From the results reported in table 1 and equation (5) in ASTM E756, the computed loss factor of a composite beam made of the characterised damping material glued to a 1 mm-thick steel beam is 0.15 at 200 Hz.

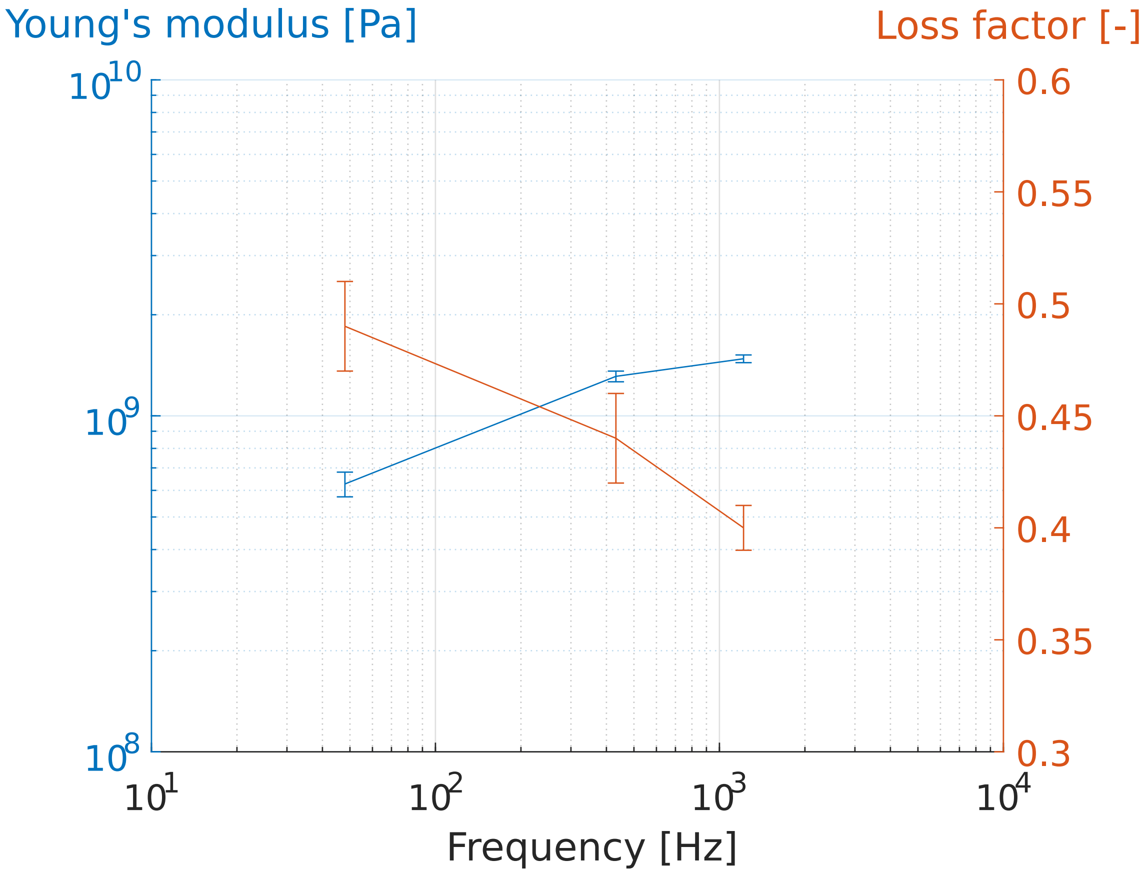

Figure 3: Graphical representation of the elastic characterisation results reported in table 1.

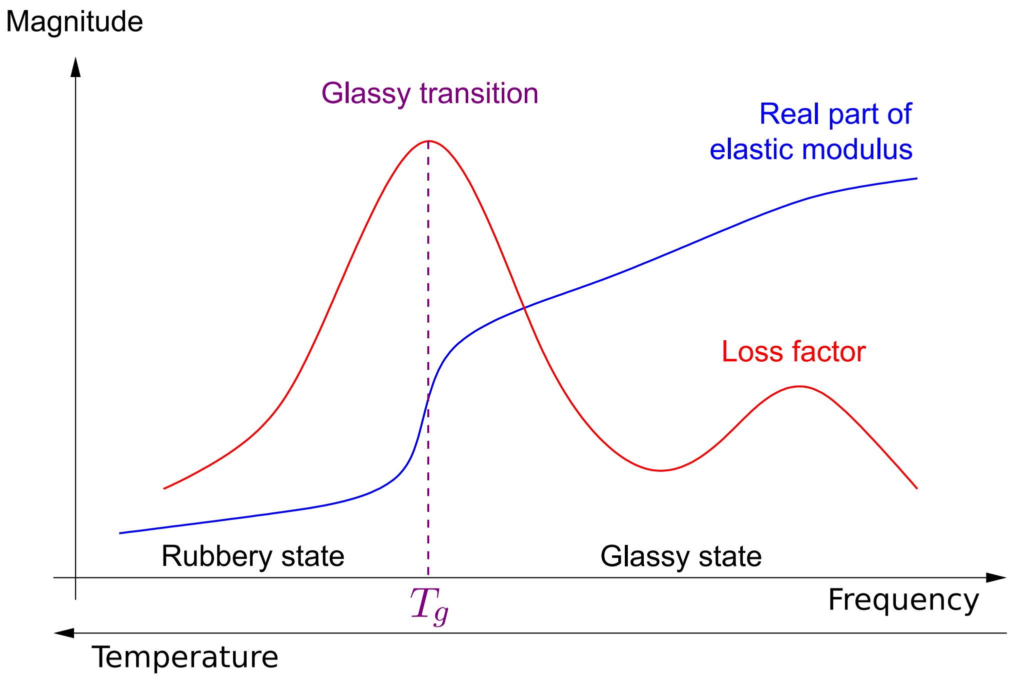

Figure 4: Scheme of the frequency and temperature superposition principle, which derives from the Time-Temperature Superposition (TTS), for a visco-elastic material exhibiting two transitions (the glassy one and a secondary one).

From a comparison of figures 3 and 4, it can be observed that the material behaves as a visco-elastic material after the glass transition (at least in the studied frequency range and at the studied temperature of 21.0 Celsius degrees).

Finally, the Poisson's ratio(s) cannot be estimated from the technique used. However, from the polymer structure of the material, values around 0.40 are expected.

Description of the characterization methods

The following pages present the method used in this report.

A Measure of the sample thickness

The thickness of the samples are measured manually using an electronic caliper with an accuracy of 0.01 mm.

For sample having an irregular surface, the kept accuracy is 0.1 mm .

For materials having a thickness larger than 10 mm and for which the surface is not flat, the thickness may be rounded to the nearest millimeter.

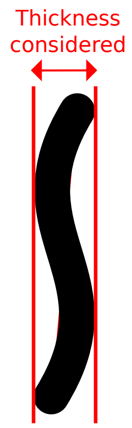

Figure 5: Material sample with a non planar surface.

B Measure of the mass density

To determine the mass density of a given sample, the weight is measured using the precision balance shown below. The thickness of the specimen are measured as described in *Section A* and the diameter of the specimen is given by the diameter of the die cutting tool given with a uncertainty of 0.01 mm.

Figure 6: Precision balance used to measure the weight of the specimens.

C Estimating the elastic and damping properties - Oberst's beam method

This method is based on the Oberst beam test as described in the standards ASTM E756 [5] and ISO 6721-3 [6] (see Fig. 7).

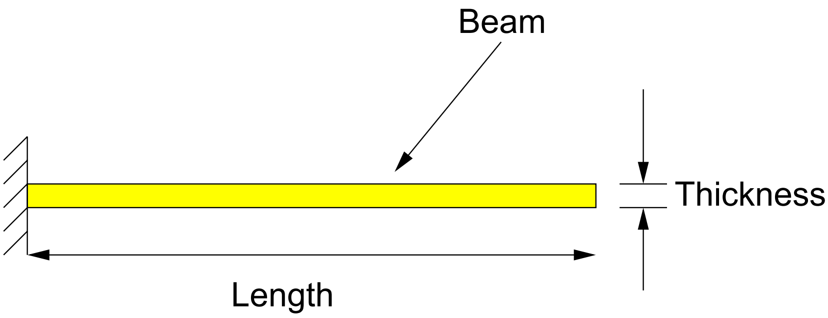

Figure 7: "Cantilever" beam used for the standard Oberst beam test.

[5] ASTM E756-98. Standard test method for measuring vibration-damping properties of materials. *American Society for Testing and Materials*, 1998.

[6] ISO 6721-3. Plastics - determination of dynamic mechanical properties of plastics - flexural vibrations - resonance-curve method. *International Standard Organisation*, 1996.

The analysis of the results are based on the measurements of the Frequency Response Functions (FRF). These FRF are defined as the ratio of the normal velocity prescribed at one end of the beam to the normal velocity measured at an arbitrary position on the beam, usually at its second end. The prescribed velocity is measured using an accelerometer placed on the dynamic shaker responsible for the excitation of the whole beam. The second velocity position is measured using a laser vibrometer to avoid any additional mass effect (see Fig. 8)..

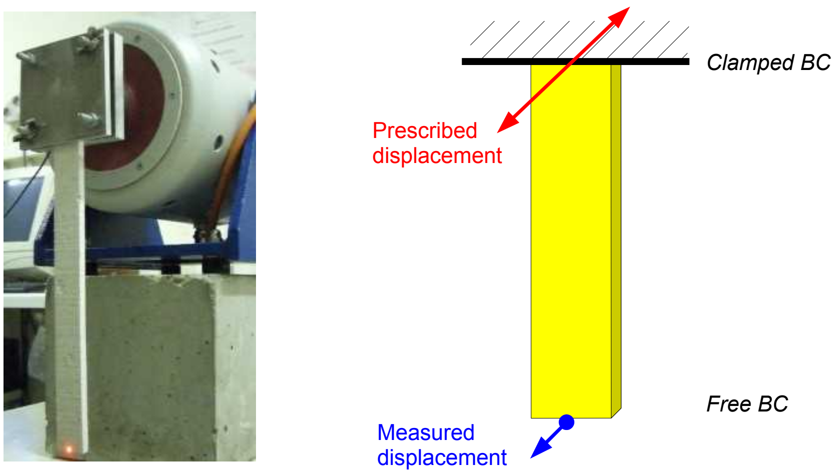

Figure 8: Example of the mounting of an Oberst beam and measurement using a laser vibrometer.

The Young's modulus and the damping loss factor, in the direction of the beam, are determined respectively from the position of the resonance frequency and from the width of the resonance peak at -n dB (n being at least equal to 3).

This method does not allow the determination of the Poisson ratio of the material.

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