Be challenging, be smart: BE CAE & Test!

Structural Analyses on 3D Printed Objects Made from Experimentally Characterized Materials

http://www.be-caetest.it/

Florence, 22-24/10/2024

COMSOL Certified Consultant

We offer **consulting** services using innovative **CAE** simulation tools and **test** facilities.

We provide our clients with **efficient** and **cost-effective solutions** to reduce time to market.

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BE CAE & Test

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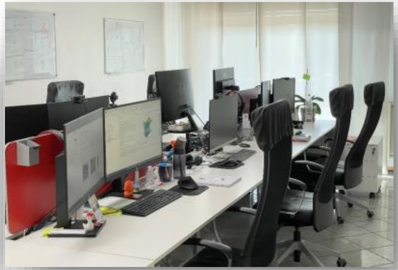
- *Calle Impresores, 20 - 28660 Boadilla del Monte (Madrid)*



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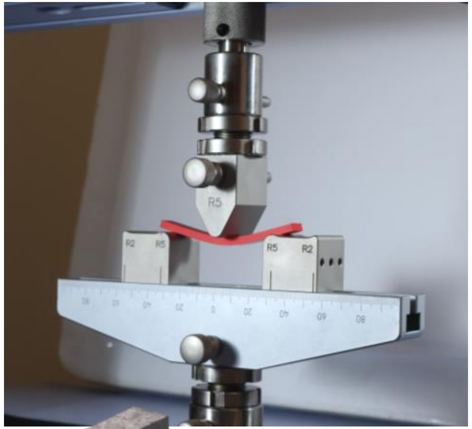
Additive manufacturing (AM) offers several key advantages, such as versatility, efficiency and customization capabilities that are transforming traditional manufacturing processes.



Steps to follow:

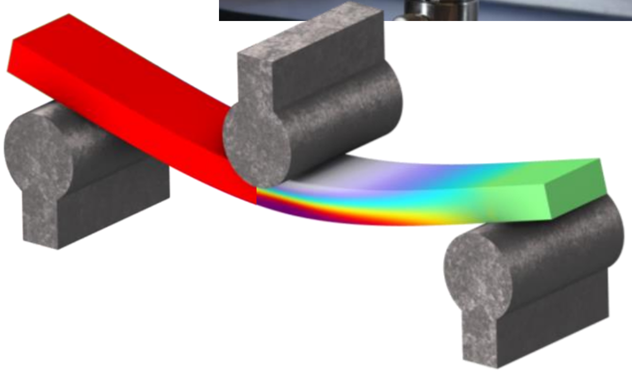
A. 3D drawing – design

B. Print parameter settings:

- Mechanical characterization of the material

  1. **3D drawing** standard specimens
  2. **Printing** standard specimens with different settings
  3. **Conducting mechanical tests**
  4. **Modelling for NUM-EXP validation**
  5. **Modelling of manufactured products**

C. 3D printing (AM)



✓ The **BE CAE & Test** company is able to follow the whole process

Let’s discover together how

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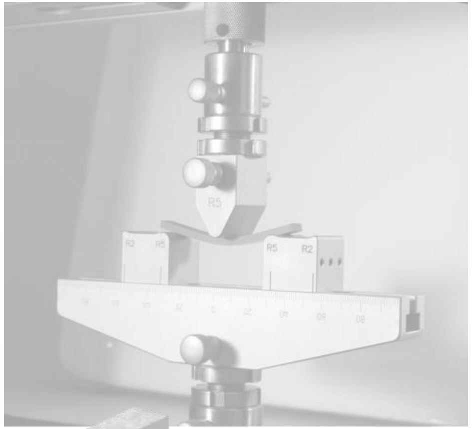

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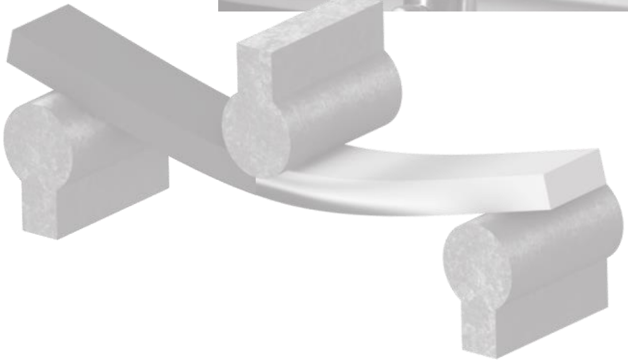


C. 3D printing (AM)

B.1 3D drawing standard specimens

Tensile test

Reference ISO 527-1-2

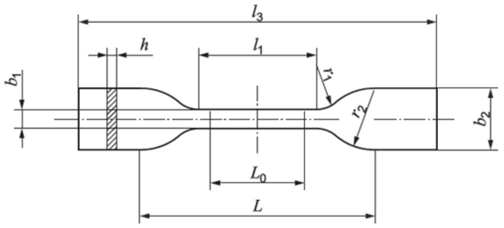
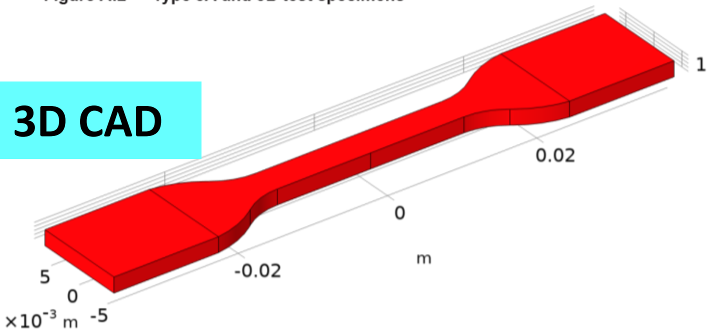


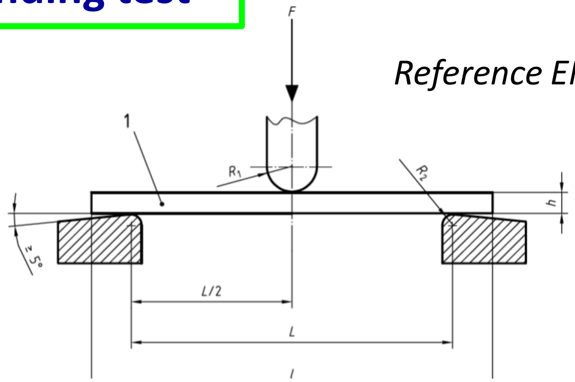
Figure A.2 — Type 5A and 5B test specimens

3D CAD

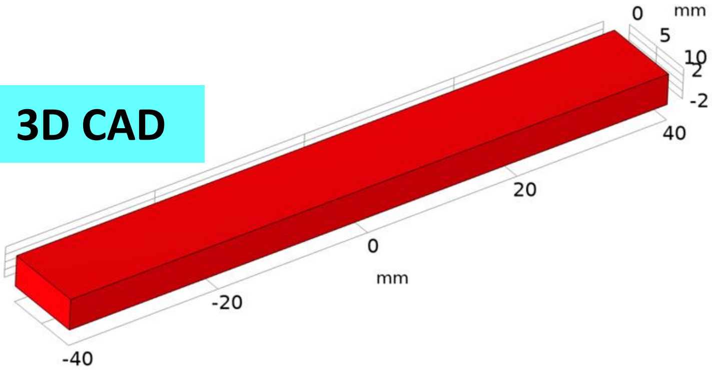


Bending test

Reference EN ISO 178



3D CAD



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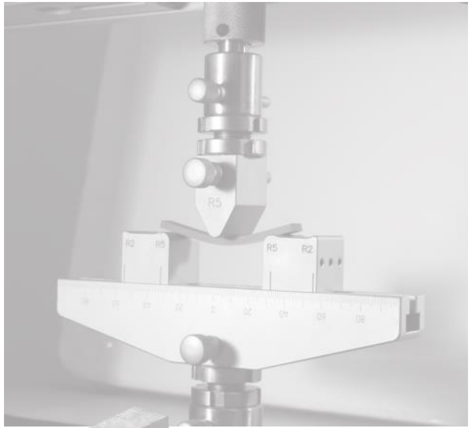

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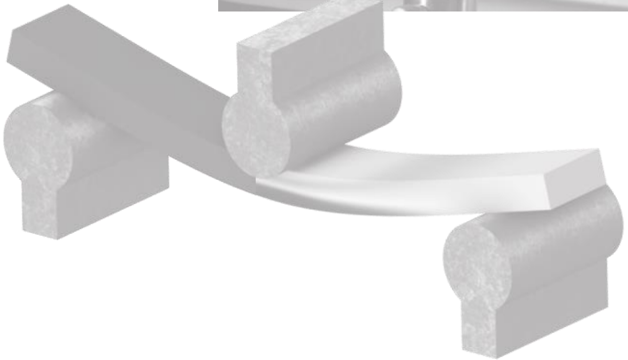
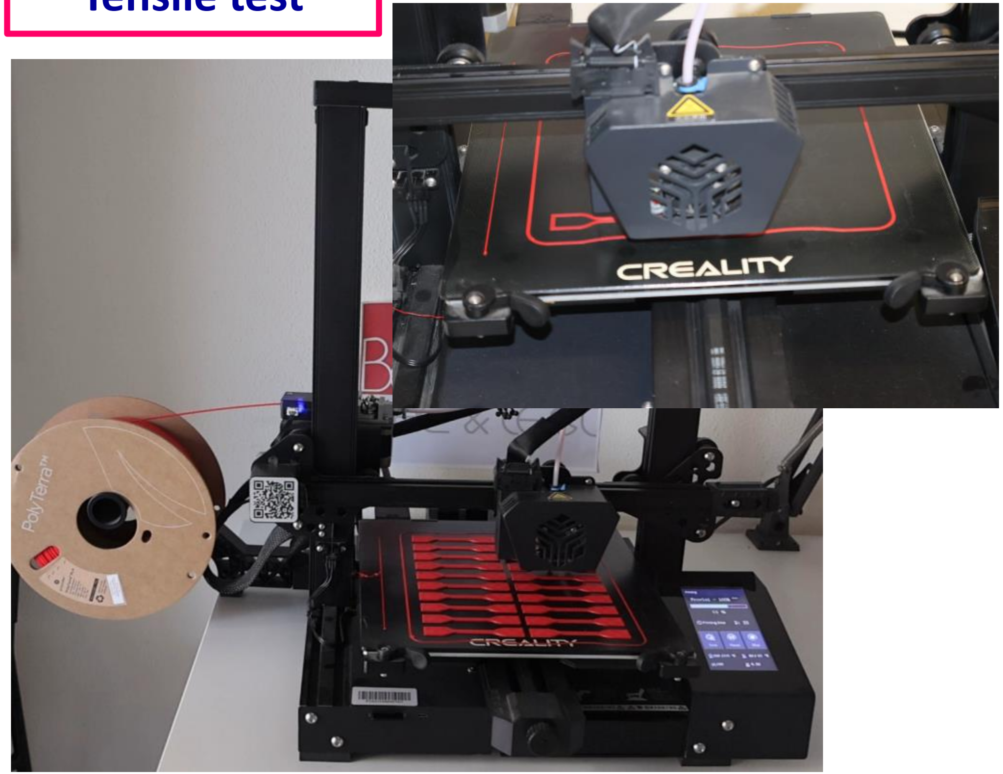


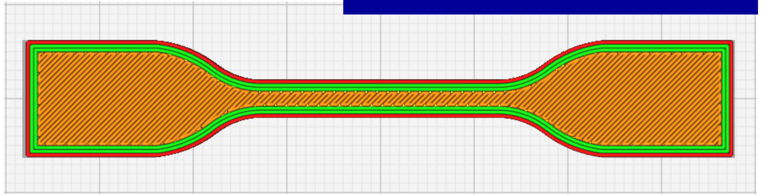
C. 3D printing (AM)

B.2 Print standard specimens with different settings

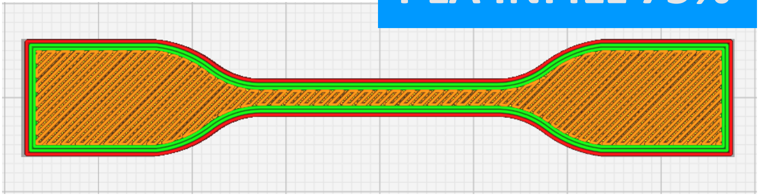
Tensile test



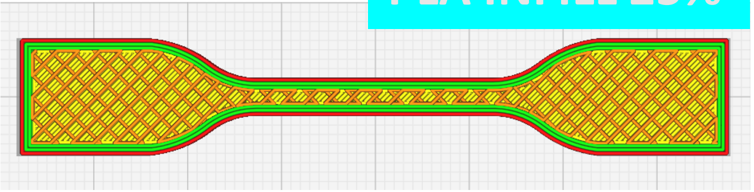
PLA INFILL 100%



PLA INFILL 75%

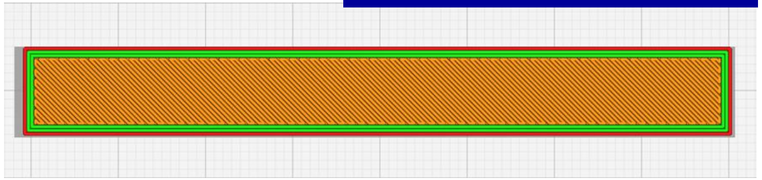


PLA INFILL 25%

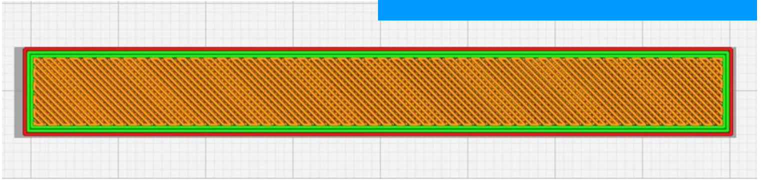


B.2 Print standard specimens with different settings

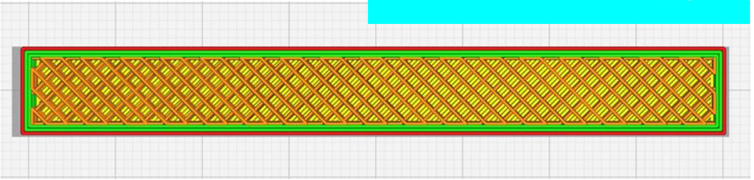
PLA INFILL 100%



PLA INFILL 75%



PLA INFILL 25%



Bending test

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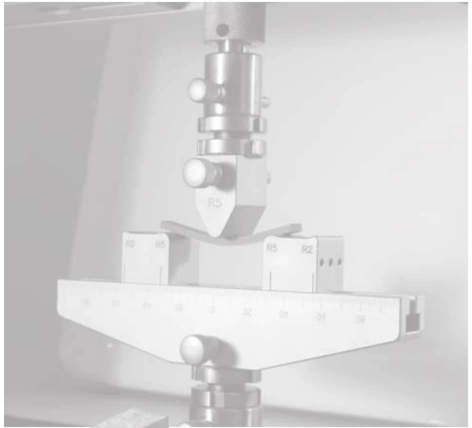
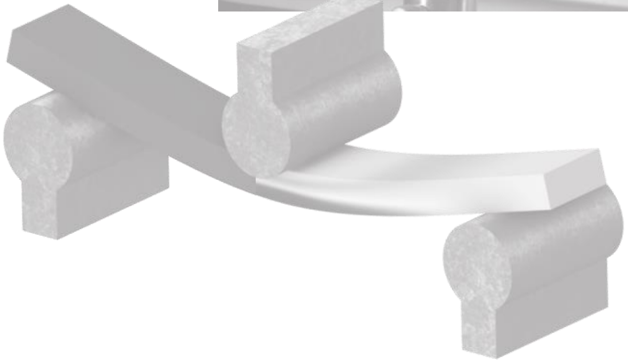
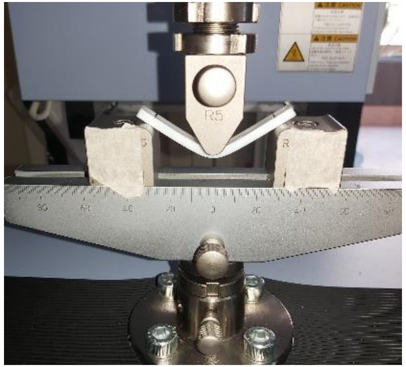




B.3 Conducting mechanical tests : Machine description





Universal machine with Thermal chamber

- Shimadzu AGS-X 10 kN
- Max. Load Capacity: 10kN
- Crosshead : Max. Return Speed: 1500mm/min
- Crosshead : Speed Range: 0.001 to 1000 mm/min (stepless)
- Thermal Chamber TCE 300: range -70°C / +280°C

B.3 Conducting mechanical tests: Test – Operating method

Test performed for **No.3** specimen **type** (PLA **INFILL 100% - 75% -25%):**

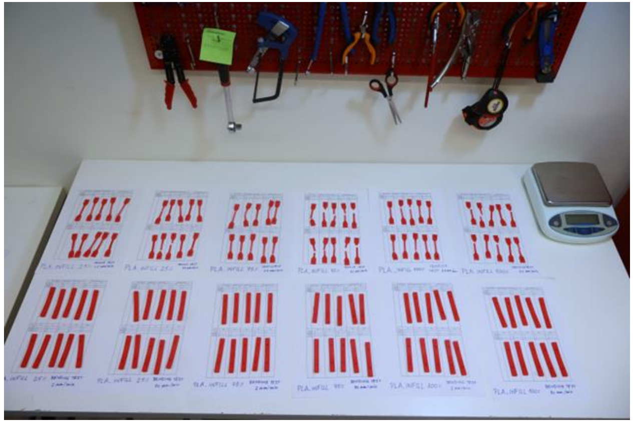
- **Tensile test** at 1-5 [mm/min] and 50 [mm/min].

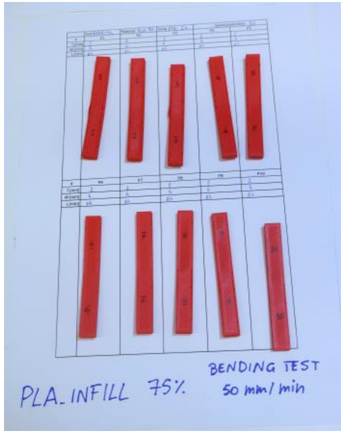
- **Bending test** at 2 [mm/min] and 50 [mm/min].

- Number of specimens: 10 per test;
- All tests performed at **(23 ± 2) °C**
- All samples are weighed

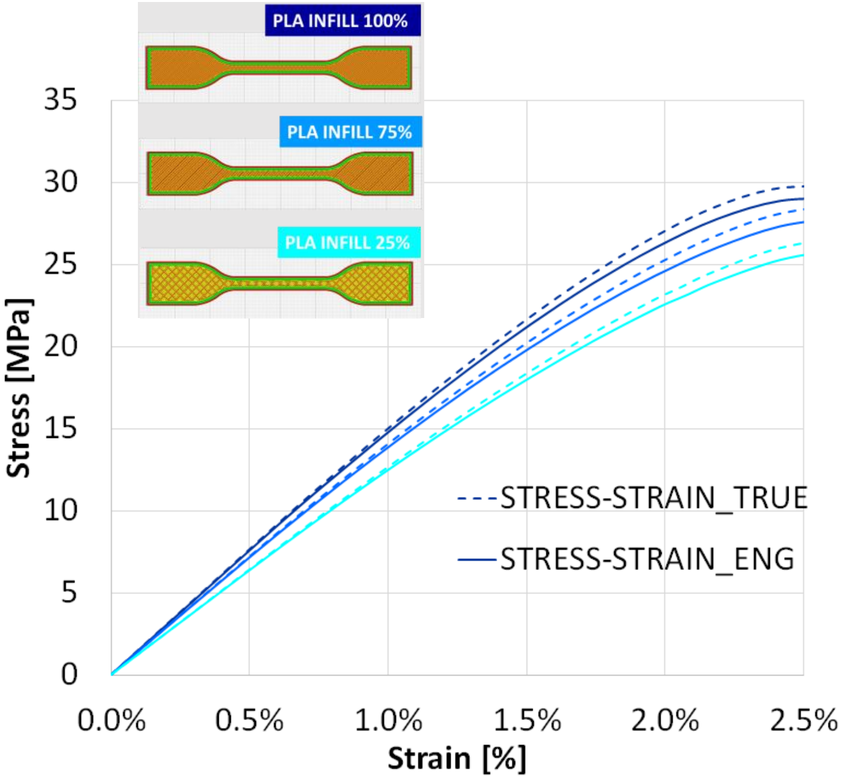
➢ The tensile test identified the **E_t** , **Yield Point** and the **Stress function** used to characterize materials in the model.

➢ **NUM-EXP validation** was carried out for tensile and bending tests.





B.3 Conducting mechanical tests: Test performed - Results



PLA INFILL 100%	
E_linear	1470 [MPa]
Yield Stress Point	26 [MPa]

PLA INFILL 75%	
E_linear	1380 [MPa]
Yield Stress Point	24.3 [MPa]

PLA INFILL 25%	
E_linear	1240 [MPa]
Yield Stress Point	23 [MPa]

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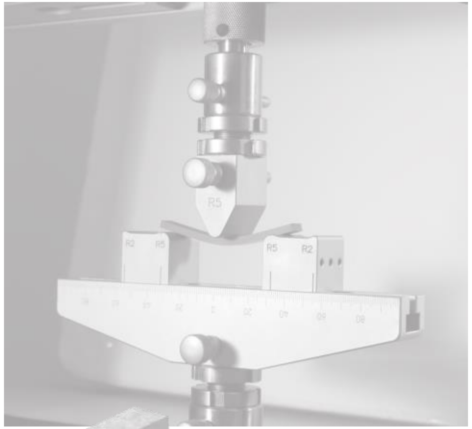

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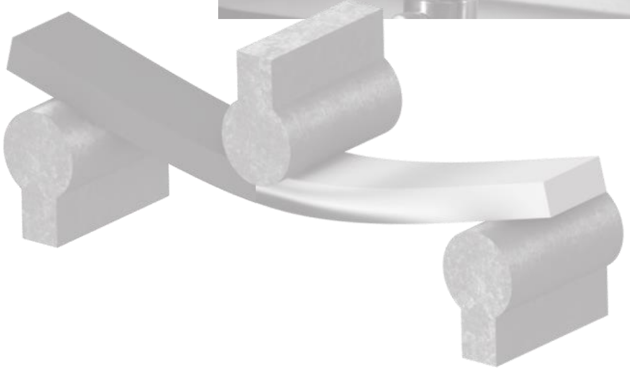
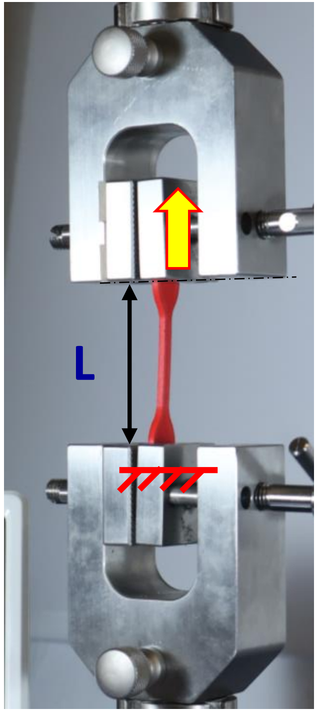


C. 3D printing (AM)

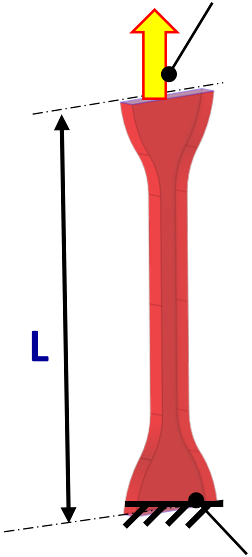
B.4 Modelling for NUM-EXP validation: Setting model – Boundary conditions

Tensile test



Prescribed displacement

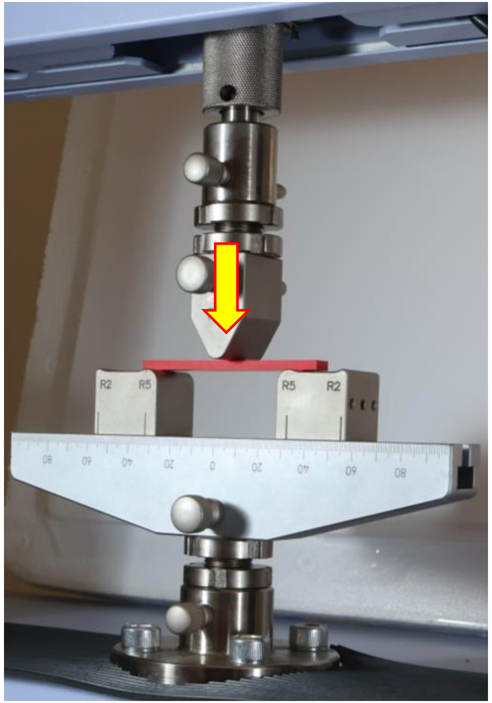
< disp>



Constraint

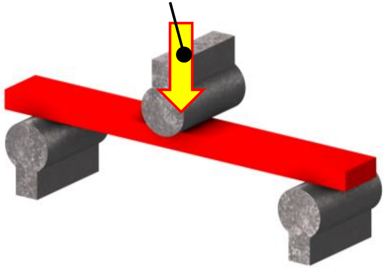
< fixed >

Bending test



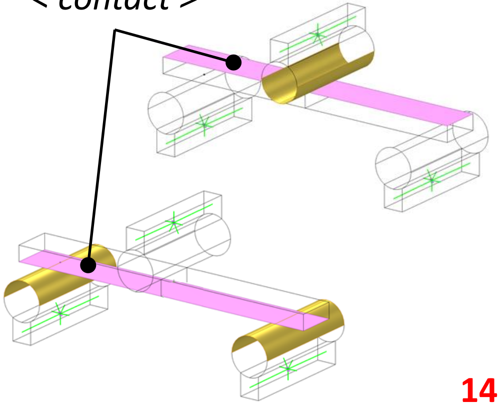
Prescribed displacement

< disp>



Identity pairs

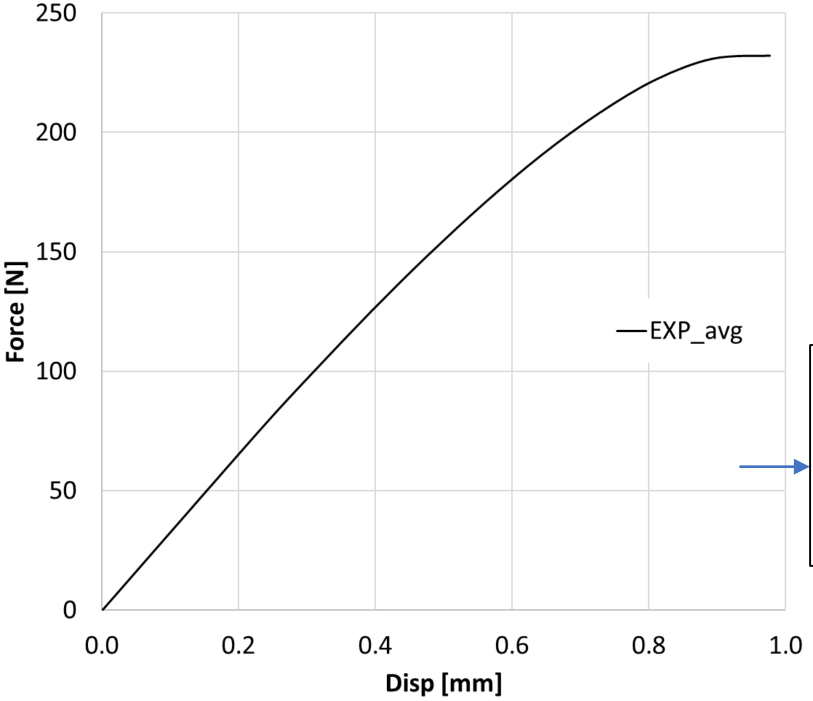
< contact >



B.4 Modelling for NUM-EXP validation: Setting model – Boundary conditions
Data processing procedure

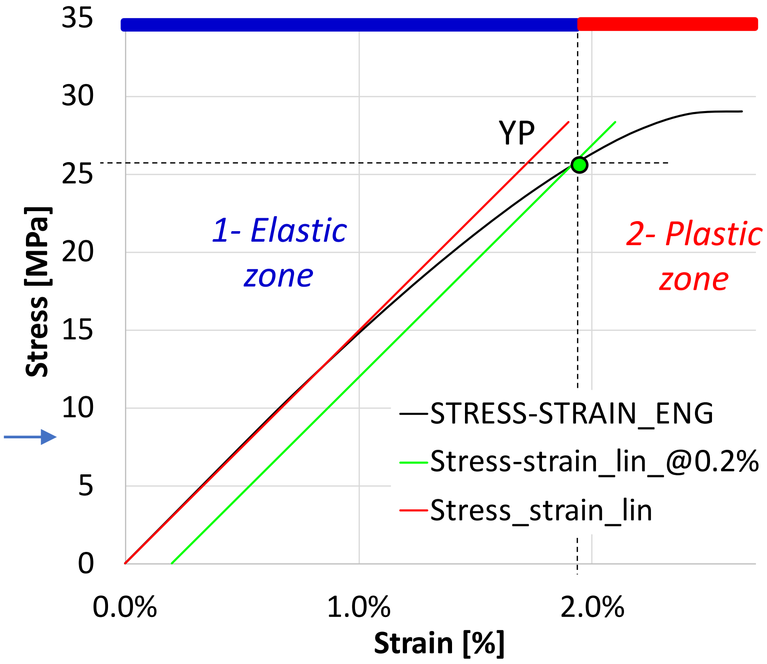
$$\varepsilon_{true} = \ln(1 + \varepsilon_{eng})$$

$$\sigma_{true} = \sigma_{eng}(1 + \varepsilon_{eng})$$



$$\varepsilon_{eng} = \frac{\Delta l}{L_1}$$

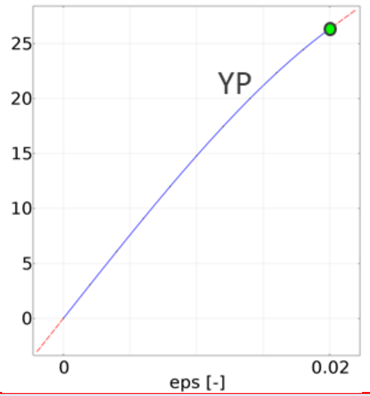
$$\sigma_{eng} = \frac{F}{A}$$



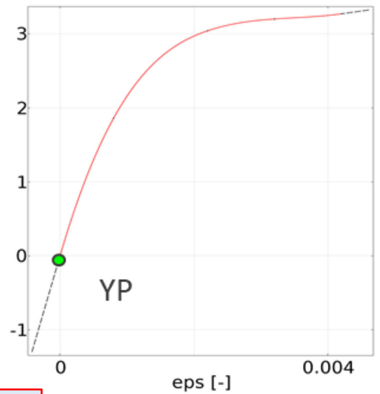
B.4 Modelling for NUM-EXP validation: Setting model Boundary conditions / Non linear elastic - Plasticity

- Solid Mechanics *(solid) {solid}*
  - Linear Elastic Material 1 *{lemm1}*
  - Free 1 *{free1}*
  - Initial Values 1 *{init1}*
  - Prescribed Displacement 2 *{disp2}*
  - Fixed Constraint 3 *{fix3}*
  - Nonlinear Elastic Material 1 *{nlemm1}*
    - Plasticity 1 *{plsty1}*
    - Equation View *{info}*
  - Equation View *{info}*

1- Uniaxial stress function



2- Hardening function



Nonlinear Elastic Material

Material model:
Uniaxial data

$\sigma_{ax}(\epsilon_{ax} = 0) = 0$

Uniaxial stress function:
σ_{ax} User defined
stress_strain_curve_eng_elastic(solid.eax) N/m^2

Specify:
Poisson's ratio

☐ Use nonsymmetric stress-strain data

Poisson's ratio:
ν From material

Density:
ρ From material

Plasticity Model

Equivalent stress:
σ_e von Mises

Initial yield stress:
σ_{ys0} From material

Plastic potential:
Q_p Associated

Equivalent plastic strain:
ϵ_{pe} von Mises

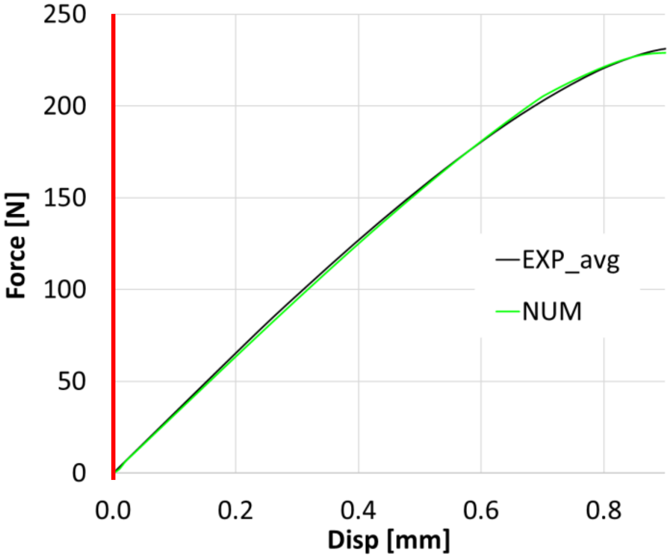
Isotropic hardening model
Hardening function

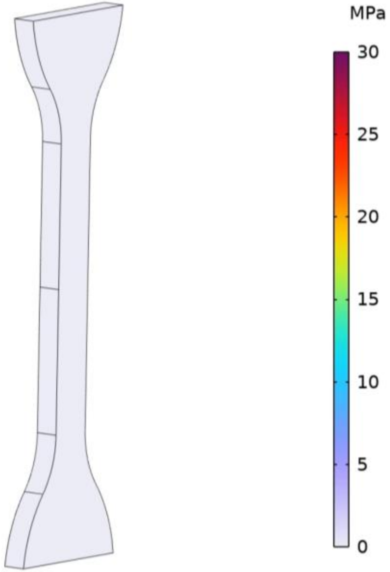
$\sigma_{ys} = \sigma_{ys0} + \sigma_h(\epsilon_{pe})$

σ_h From material

B.4 Modelling for NUM-EXP validation: Results

- Plots on the right: Force [N] - Disp [mm]comparison between Numerical (**green curve**) and Experimental data (**black curve**)





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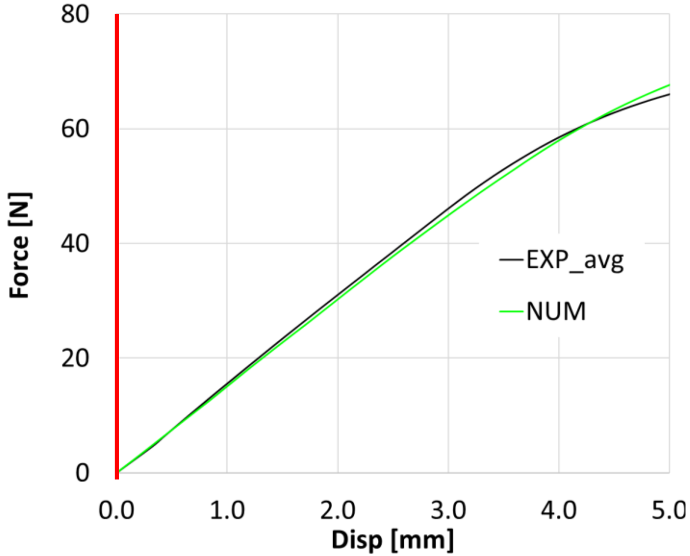

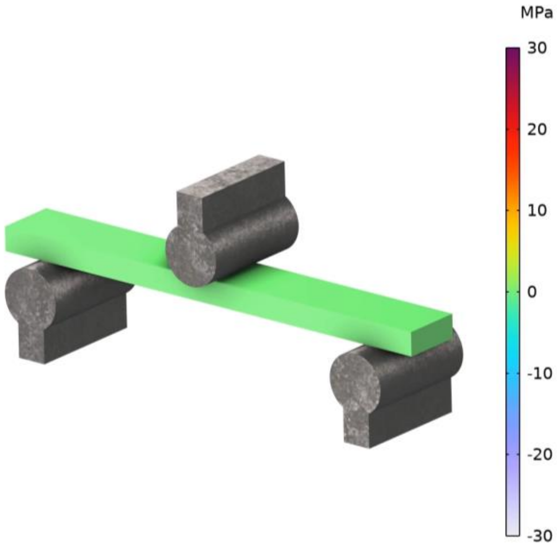

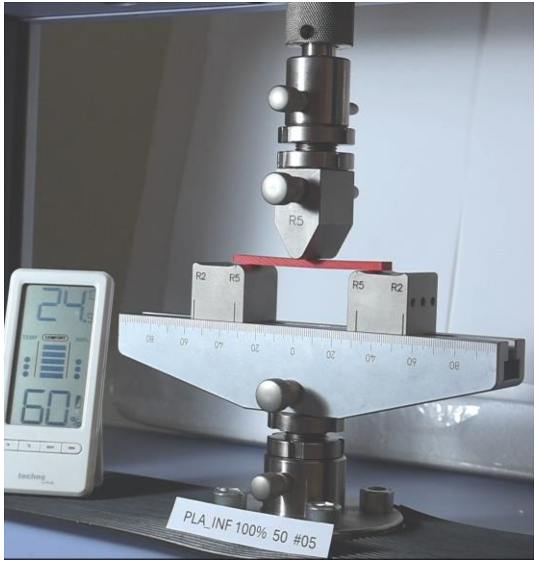

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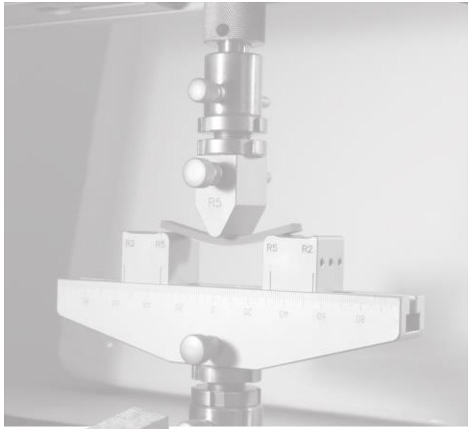

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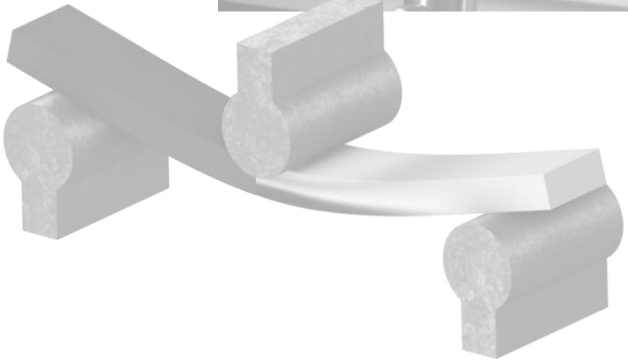
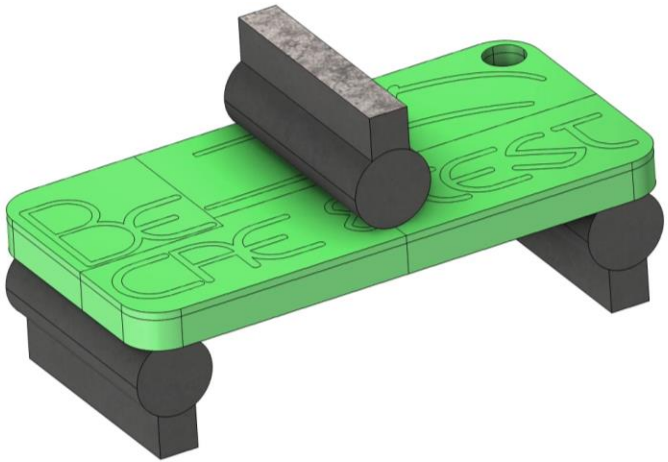
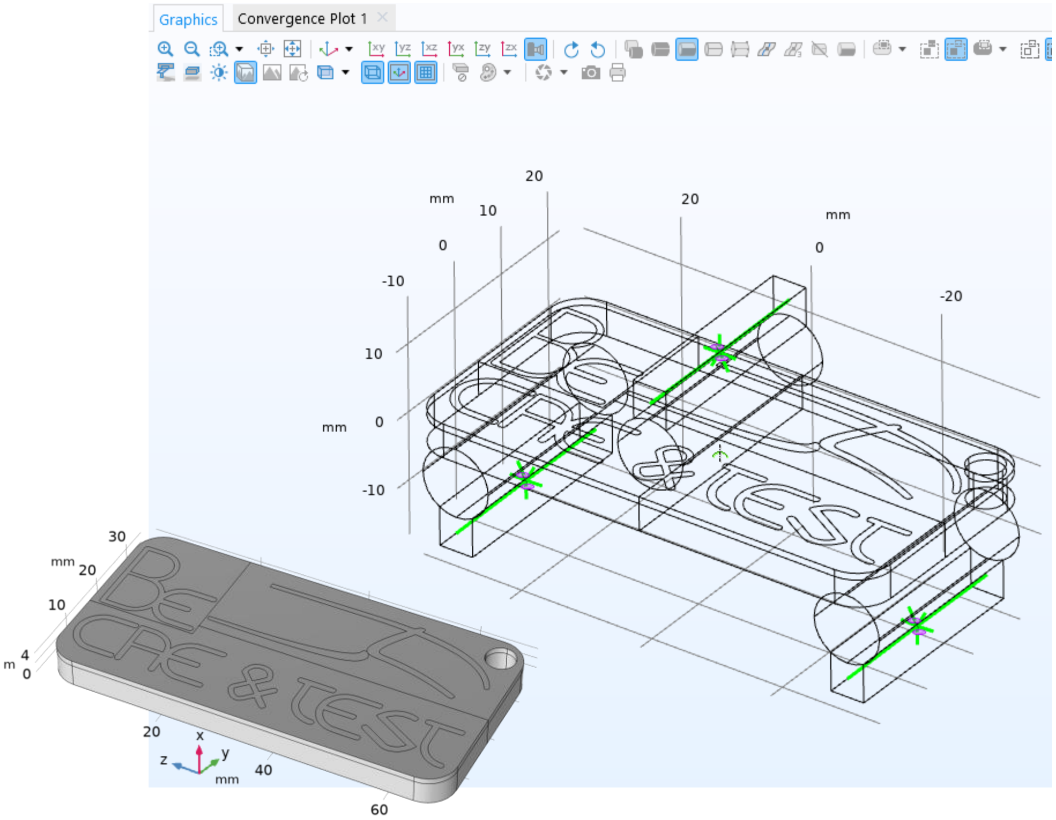


B.5 Modelling of manufactured products





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C. 3D printing (AM)

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So…
If you want more information, that is not available, about the print settings for 3D products:

- ✓ Get standard-sized samples prepared;
- ✓ Send the samples to BE CAE test.

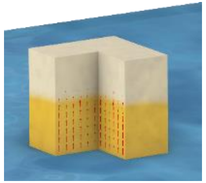
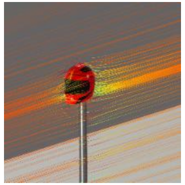
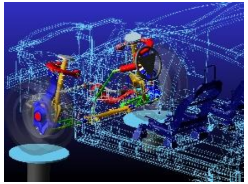
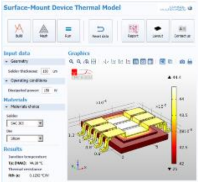
We will analyze:
- ✓ The material characteristics based on the various print settings.

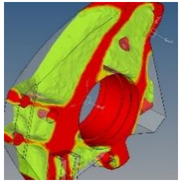
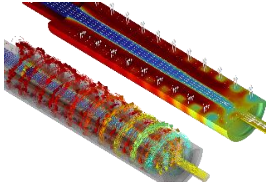
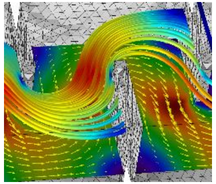
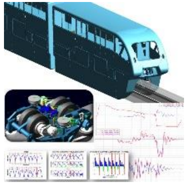
Finally, we will use the Structural Mechanics module to:

- ✓ Identify the ideal dimensions of the object;
- ✓ Avoid unwanted breakage under certain loads;
- ✓ This will save **time** and **money**

"Don't miss out!
Stop by our booth to claim your exclusive free gift—while supplies last!"

Thank you all for your attention!

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