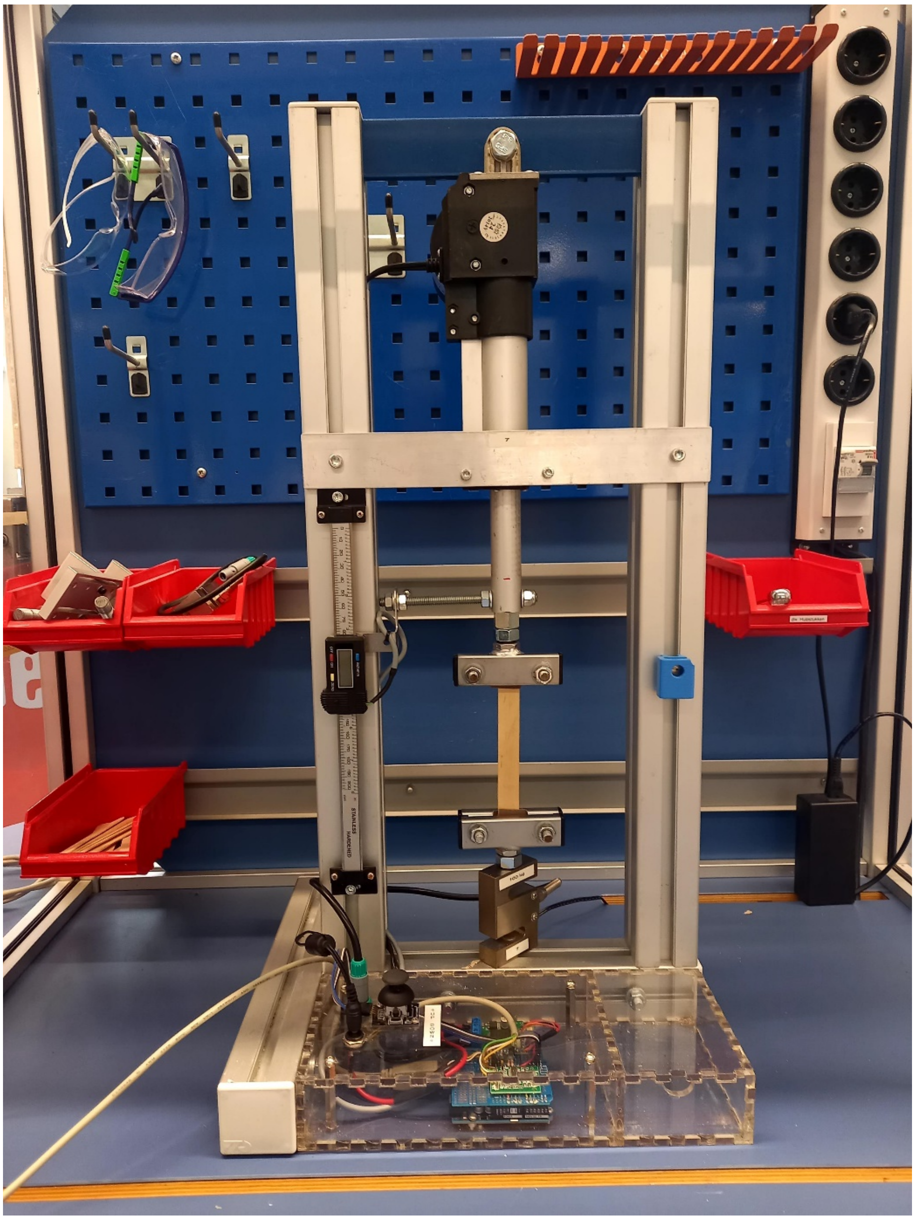
MARCH 12, 2024



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TU DELFT

Contents

The LETT

The LETT (Low-End Tensile Tester) is a tensile test machine, especially built for education purposes at IDE, TU Delft. The machine can be used to do tensile tests, 3-point bending tests and compression tests to determine material properties such as the Young's modulus and the tensile strength.

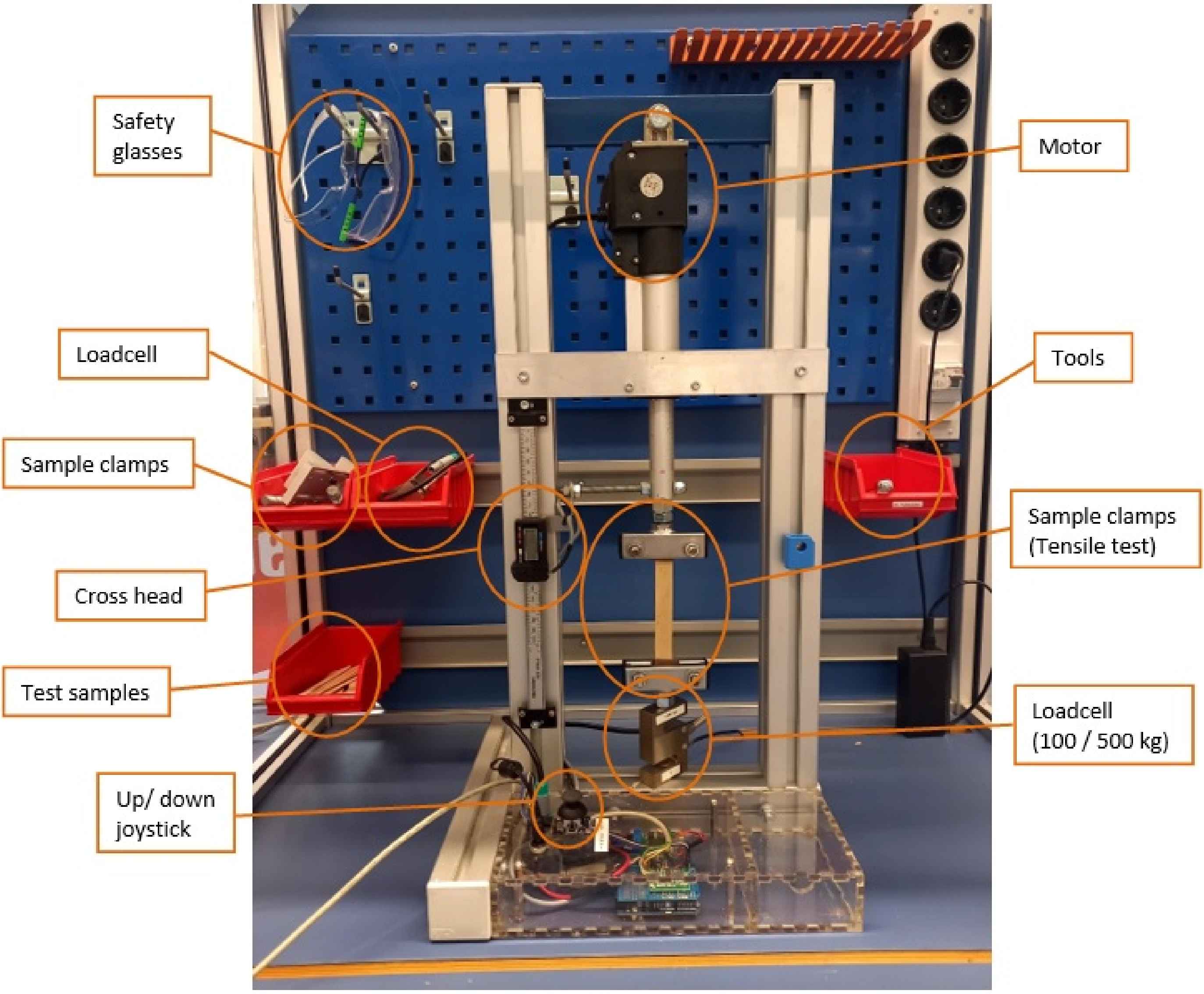


Figure 1: LETT

The motor drives the top-clamp in the Z-direction while the Loadcell measures the force and the Cross head measures the Z-travel.

The machine can be setup for test till failure, for testing creep and relaxation and for cyclic tests.

You can setup a measurement by choices in hardware, the loadcell and the clamps, and choices in the software, see the next Paragraphs.

Keep the window down during the tests as protection against splinters. If you really need the window to be open during the experiment wear safety glasses and make sure the people around you are safe.

Hardware

To setup the hardware you can choose the load cell and the clamps.

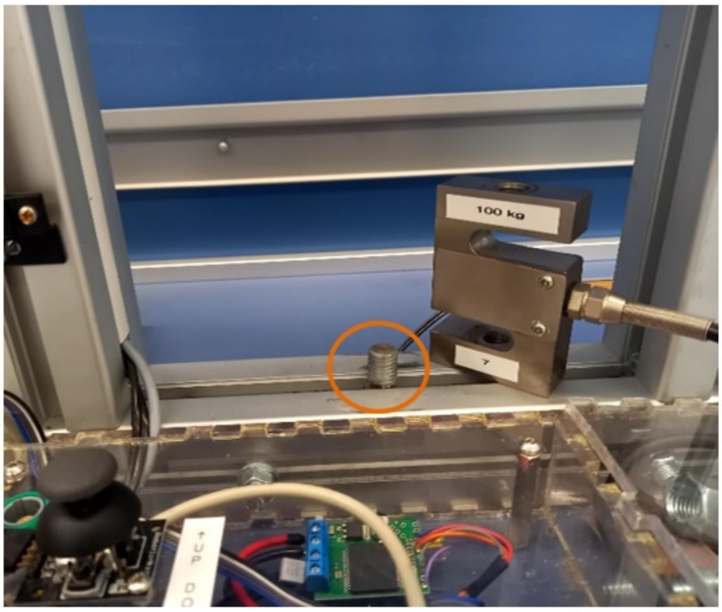
If you need to move the clamps in order to (dis)connect hardware, first connect the LETT with the USB to your laptop and use the joystick to move up and down.

Choose the force sensor

There are 2 options:

a. 100 kg / 1000 N
b. 500 kg / 5000 N

The force gauge can be fixated on the M13 bolt end in the bottom of the LETT, hand tight. The sensor doesn't have to be aligned with the machine.



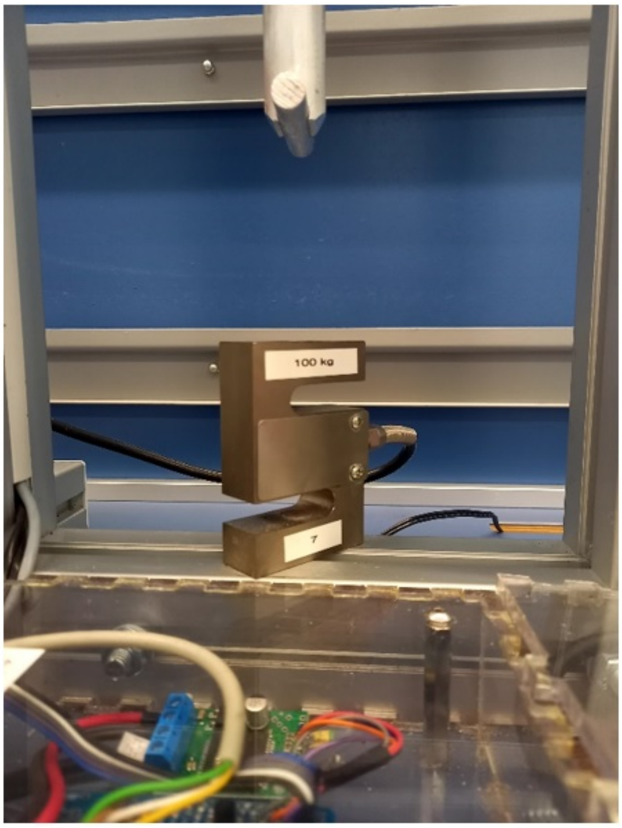


Figure 2: Force sensor connection

Choose the clamps

The clamps can be changed by loosening the M13 fixation nuts that holds the clamp to both the top end of the machine and the force gauge with a spanner size 19, hand tight.

- **a.** Tensile test (spanner 13)
- **b.** Tensile test for small samples (spanner 13)
- **c.** 3-point bending test (Allen key 3)
- **d.** Compression test

a. In the **tensile test setup**, align the clamps such that the sample will be straight, fixate the clamps hand tight using the fixation nuts, make sure that the M8 nuts are on the front to change samples easily, see figure 3.

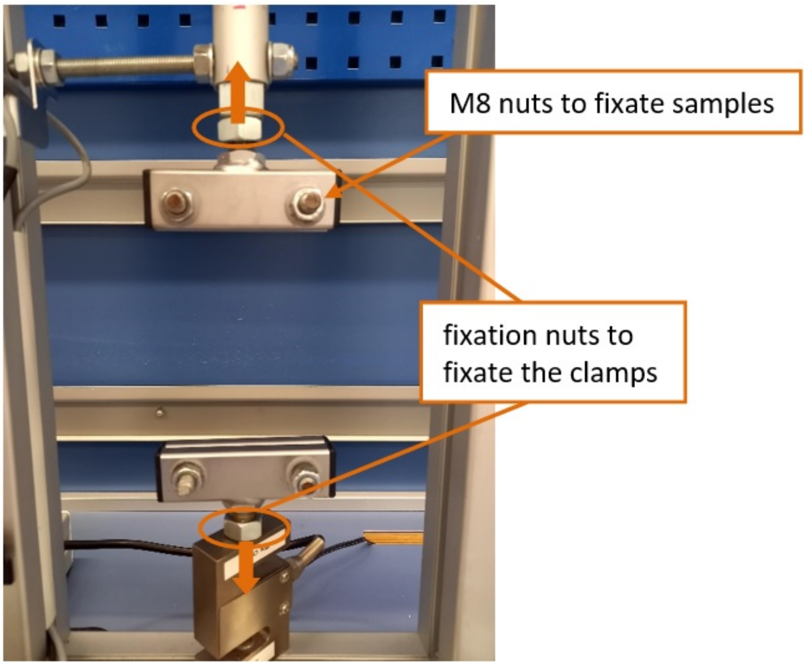


Figure 3: Tensile Test clamps

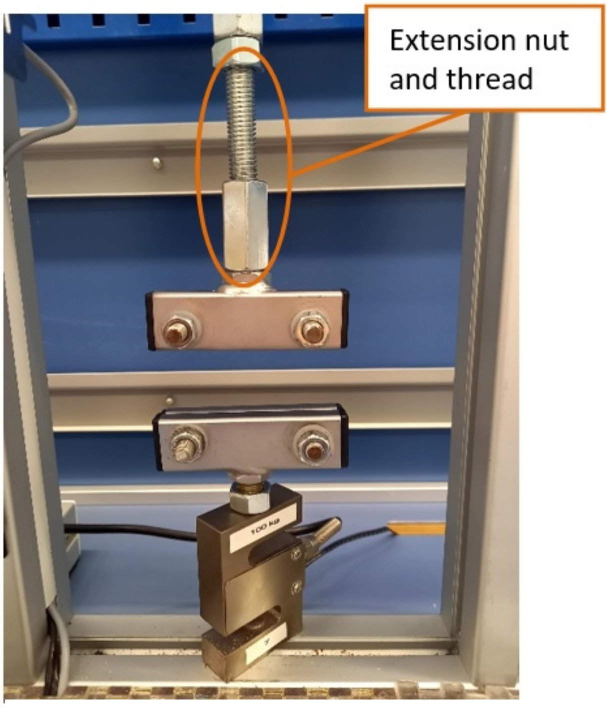


Figure 4: Tensile Test for small samples

b. In the **tensile test setup for small samples**, add the extension nut and thread to the tensile clamps, align the clamps such that the sample will be straight, fixate the clamps hand tight using the fixation nuts, make sure that the M8 nuts are on the front to change samples easily, see figure 4.

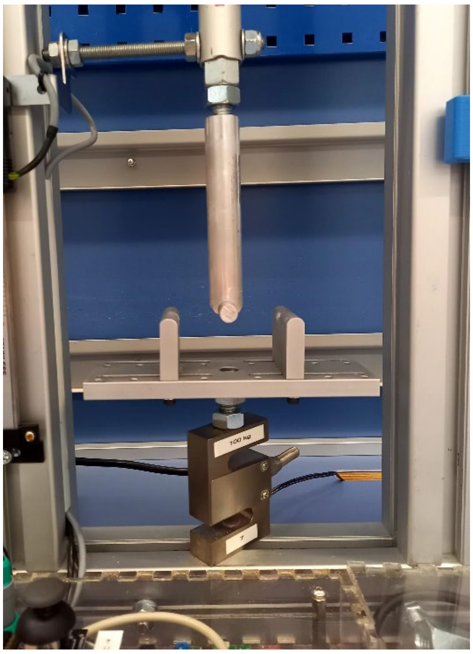


Figure 5: 3 Point Bending Test clamps

c. In the **3 point bending setup**, align the clamps such that the top support and the bottom supports are aligned with each other and preferably aligned with the machine, fixate the clamps hand tight using the fixation nuts, see figure 5. The bottom supports can be adjusted with an Allen key size 3, either to fixed positions or to the slots, see figure 6.

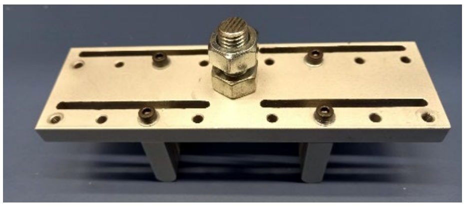


Figure 6: Adjustable bottom supports

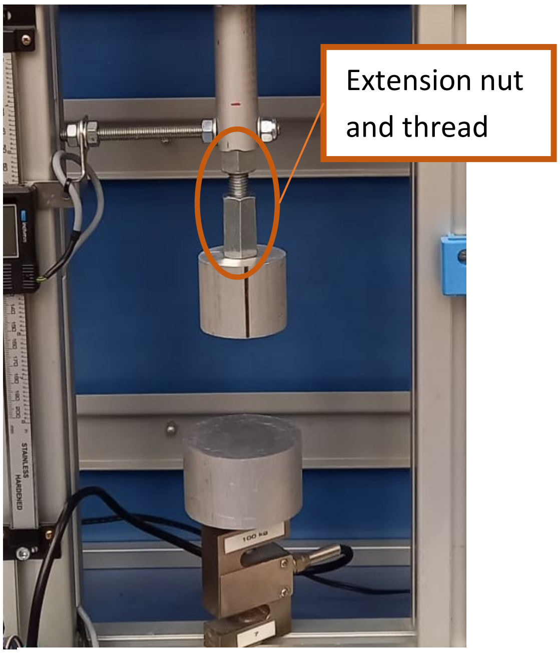


Figure 7: Compression clamps

d. In the **compression setup**, use the extension nut and thread from the tensile setup for small samples, fixate the clamps hand tight using the fixation nuts, see figure 7.

Software

For the software there are 2 options: use the website, or use the (older) software

Website

1. Connect the LETT with the USB to your computer
2. Use Google Chrome or Microsoft Edge to go to edu.nl/7fxup (it does not work on Firefox or Safari)

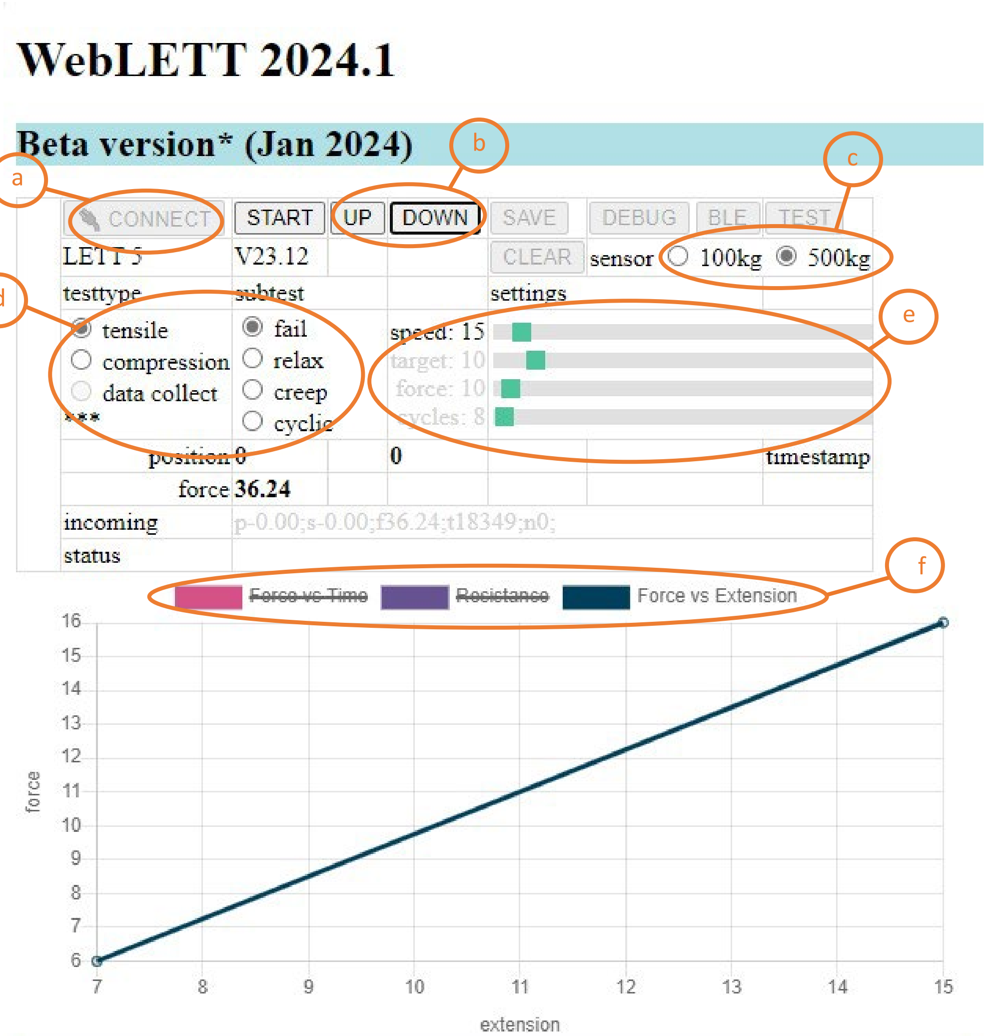


Figure 8: User Interface LETT website

a. Click on **CONNECT, c**hoose the correct serial-port (mostly it is called 'Arduino Uno') and click on **CONNECT**
b. Use the **UP** and **DOWN** buttons to confirm a proper connection between LETT and computer
c. Ensure that the sensor selected in the top right **(100kg or 500kg)** matches the force sensor on your LETT machine.
d. Choose the correct test:
   - *tensile* for the Tensile Test and the Tensile Test for small samples
   - *compression* for 3-point Bending and Compression
   - *fail* to test till failure
   - *relax.* to apply displacement and measure force
   - *creep* to apply force and measure the displacement
   - *cyclic* to repeat motion and measure hysteresis effects
e. Fill in the test parameters: speed [mm/min], target (position) [mm], force [N] and/or cycles [-] by moving the slides.
f. Choose the type of graph you want to see

Java-program

1. Install Java Runtime Environment from: https://www.java.com/en/download/manual.jsp
2. Download and **save** the LETT software from edu.nl/bcpk8
3. Extract the Zip-folder **LETT2023** to a suitable location.
4. Connect the LETT USB cable to your computer.
5. Open the **LETT2023.jar** file. The following window will pop up, it might take a minute:

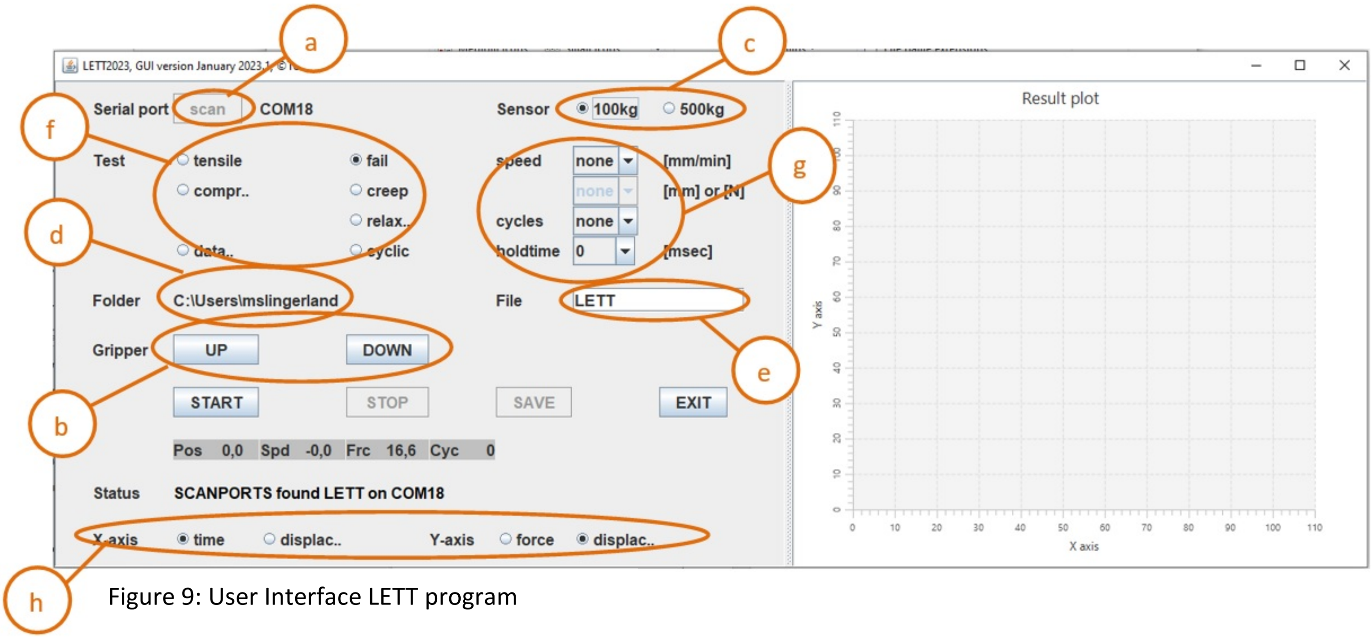


Figure 9: User Interface LETT program

a. If no port is displayed, check the connection between LETT and your computer and press the **scan** – button.

b. Use the **UP** and **DOWN** buttons to confirm a proper connection between LETT and computer.

c. Ensure that the sensor selected in the top right **(100kg or 500kg)** matches the force sensor on your LETT machine.

d. Click the bold text next to **Folder** to choose a location to save the test results. This will create a subfolder named LETTResults where tests will be stored.

e. Choose a file name for the test results.

f. Choose the correct test:
   - *tensile* for the Tensile Test and the Tensile Test for small samples
   - *compr.* for 3-point bending and Compression
   - *fail* to test till failure
   - *creep* to apply force and measure the displacement
   - *relax.* to apply displacement and measure force
   - *cyclic* to repeat motion and measure hysteresis effects

g. Fill in the test parameters: speed [mm/min], force [N], position [mm], cycles [-] and/ or holdtime [s].

h. Choose logical X- and Y-axis (displac.[mm] and force [N] for testing till failure and cyclic testing, time [s] and displac. [mm] for creep and time [s] and force [N] for relax.)

Preparing Your Samples

Make sure all your samples have the same dimensions, preferably in dogbone-style for tensile tests and straight/ rectangular for 3 point bending tests. Label them according to the test order.

Figure 10: Sample shapes

Measure the width and thickness of your samples and record the values in a table like Table 1.

Value Measured	**Sample 1**	**Sample 2**	**Sample 3**
Width 1			
Width 2			
Width 3			
Width Avg. (*w*)			
Thickness 1			
Thickness 2			
Thickness 3			
Thickness Avg. (t)			
Gauge Length (Lo)			
Area (A=w*t)			

Table 1: Sample Dimensions

Example test: a Tensile Test till failure

1. Install the needed loadcell and clamps, see chapter 2.
2. Move the clamps with either the joystick (slowly) or the “**UP/DOWN**” buttons on the interface.
3. Place the sample on the tester:
   a. Clamp your sample to the bottom grip.
   b. (Un)screw the bottom grip until it aligns with the top.
   c. Make sure the sample is straight and clamp the top.

NOTE: If the sample slips, use sand paper between the sample and the grip.

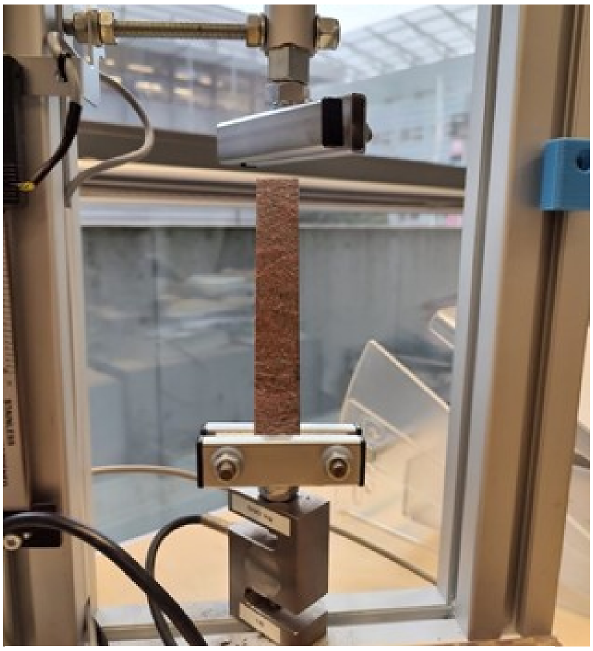


Figure 11: Clamp in the sample

4. Close the window as your splinter protection (if not, use safety goggles)
5. Set the test mode to **tensile** and **fail**.
6. Set test speed to **5mm/min.**
7. Choose the Force vs Extension graph, or, in the Java-program change axes to **displacement** (X axis) and **force** (Y axis).
8. Begin test with “**START**“ button.

(the **STOP** button is used to cancel test).

9. Use “**SAVE**” to save the data
10. Repeat for all your samples.

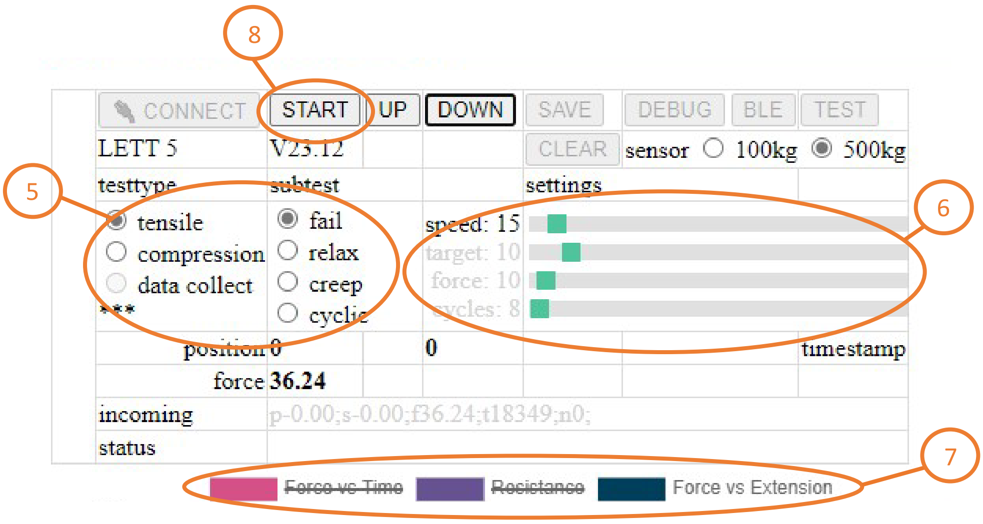


Figure 12: Adapt the test in the software

Analysis

Open the saved file from the location you saved it (C:\\Users\NAME\Documents\LETTResults) in Excel or import it into Excel. You might need to split the columns, see next paragraph, figure 14.

Convert the obtained load-displacement data to stress-strain and plot. (More information here).

$$\sigma = \frac{F}{A}; \; \varepsilon = \frac{\Delta l}{l_o}$$

in which:

σ - stress

F - force values recorded

A - cross-sectional area of sample

l_o – gauge length

ε – strain

Δl – displacement

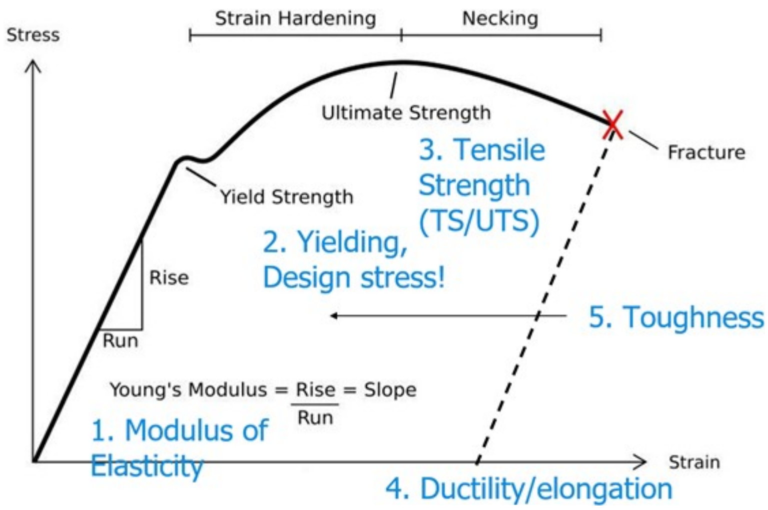


Figure 13: Charasteristics of a Tensile Curve

Use Figure 13 to calculate the six major tensile properties of your curve.

1. Modulus of Elasticity or Young's Modulus (E) – the slope of the linear section of your curve.
2. Yield strength (σ_Y) – transition from elastic to plastic (permanent) deformation.
3. (Ultimate) Tensile strength – top of the curve
4. Ductility – amount of elongation at fracture.
5. Toughness – area under the curve
6. Breaking strength – end point of the curve

Handy features in Excel

- The data file uses the following units: Time in seconds [s], Extension (or displacement) in millimeter [mm], Force in Newton [N], Resistance in Ohm [Ω] and Temperature in degrees Celsius [°C] (where the last 2 are only available on 2 LETT's).
- You might need to split the data into separate columns, use this feature in Excel:

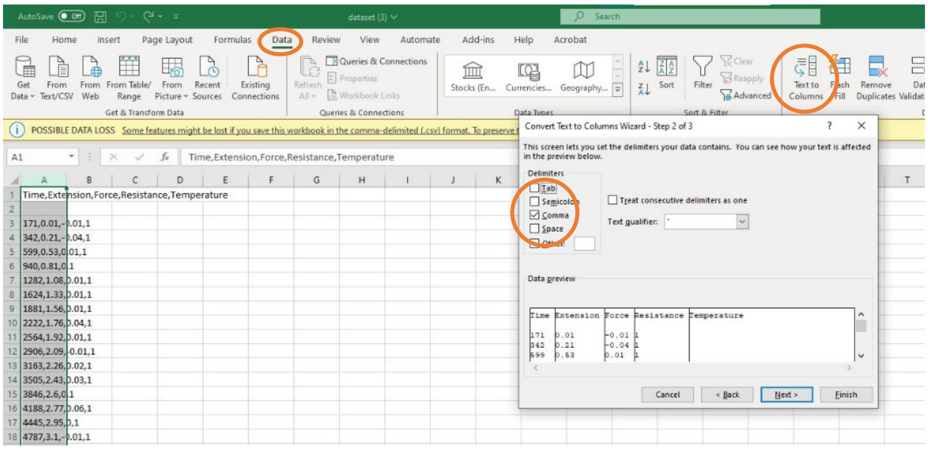


Figure 14: split columns in Excel file

- In the data the decimal point is used; you might need to change this into a comma to be able to do calculations and make graphs. Highlight the data, click on **find & select** on the **home** tab and then choose **replace**.

Youtube links

- Stress and Strain - https://www.youtube.com/watch?v=aQf6Q8t1FQE
- Material Strength, Ductility and Toughness - https://www.youtube.com/watch?v=WSRqJdT2COE
- Young's modulus - https://www.youtube.com/watch?v=DLE-ieOVFjI
- Poisson's Ratio - https://www.youtube.com/watch?v=tuOlM3P7ygA

Literature

- Materials : engineering, science, processing and design from M.F. Ashby - https://tudelft.on.worldcat.org/v2/oclc/852806045