Experiment:
Determination of the shear center position for an open section thin walled beam

1. Introduction, general description

The proposed experiment aims to experimentally detect the position of the shear center of a thin-walled beam with an open cross-section. The beam is positioned on two supports at the ends and loaded by a force in a central position (Fig. 1). The point of application of the force can be moved in chord direction, in order to measure the rotation of the section and determine the position of the force corresponding to a null rotation of the section. This position corresponds to the position of the shear center.

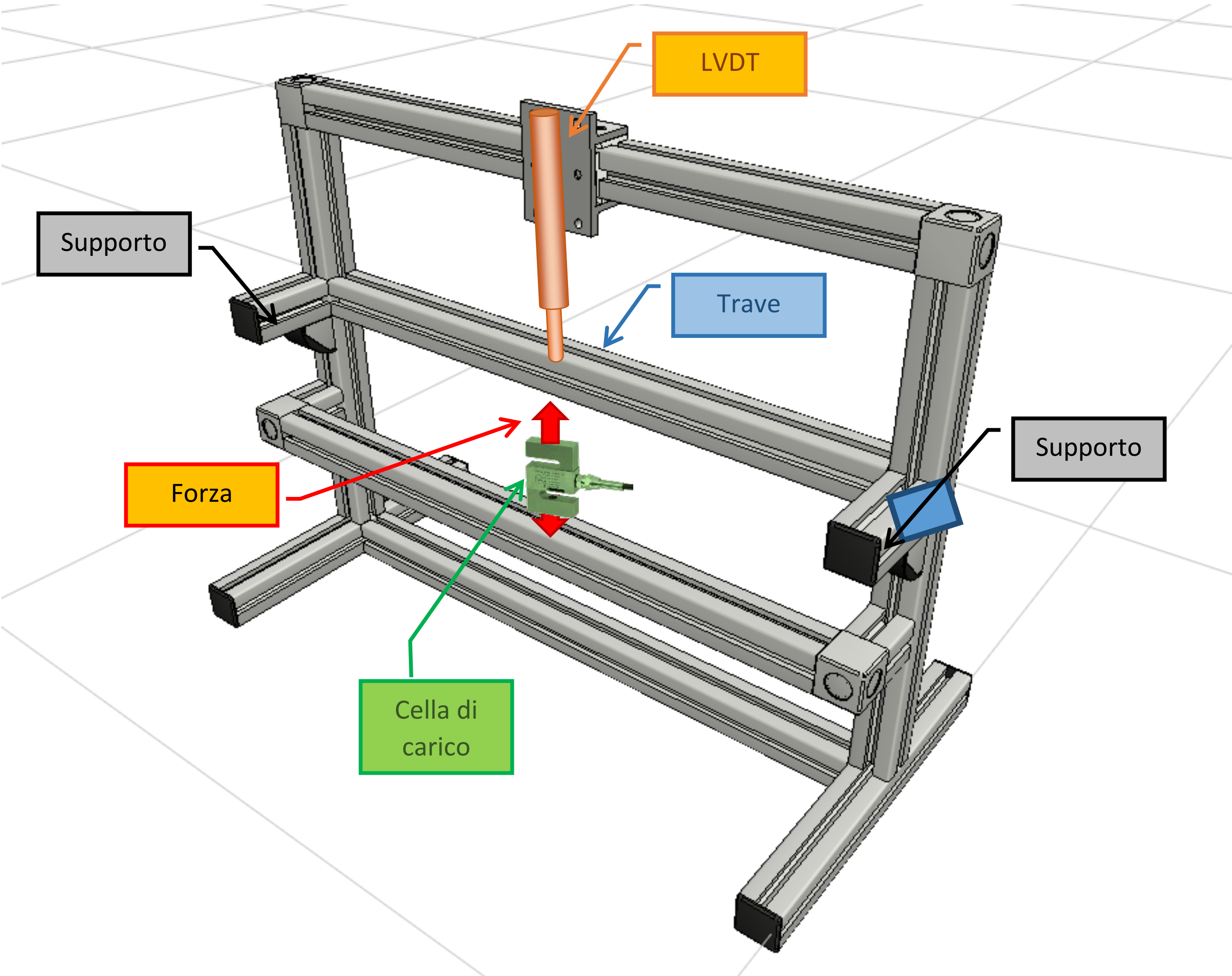


Fig. 1 – Loading frame for the experiment

The nominal characteristics of the beam will then be updated according to the measurements made on the beam object of the experimental test.

The measure of displacement will be made by means of a displacement transducer of the type LVDT (Linear Variable Differential Transformer. The measure of the force will be made by means of a strain-gage load-cell (where the force is first converted in mechanical strain which in turn is measured with a bridge of electrical resistance strain-gages).

The force, measured by the load-cell, will be generated by means of a screw manually actuated. The screw will produce the force that will pass through the load-cell (where it will be measured) and will be applied to the center point of the beam

The system shown in Figure 2 allows the displacement of the force application point and the variation of the position of the displacement transducer along the chord direction of the beam for measuring the displacement of the flange in several points..

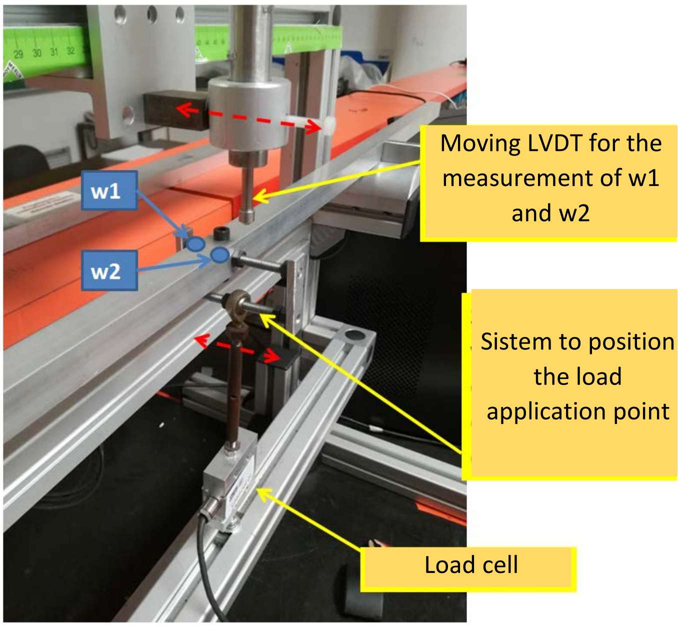


Fig. 2 – System for moving the force application point and displacement measurement

Measuring the displacement in at least two points (w1 and w2) of the section it will be possible to evaluate the rotation which will be proportional to the difference of the two values Δw.

The measurements of the values of force and displacement will be performed by means of a two channels (one for the force, the other for the displacement) data acquisition board connected to the PC. A program developed in NI LabView® will be used to get the measures of force and displacement. The values will be then recorded (on paper or in electronic form) for subsequent examinations and to prepare the evaluation document to be completed in the provided tab on each own personal page of the Educational Portal.

Note: the exercise is set in order to measure force and displacement samples simultaneously.

1.1. Procedura

The experiment will be developed as follows (after the preparation of the setup, transducers, and connections):

a) Alignment of the beam on the supports and of the point of application of the force on the centerline.
b) Positioning of the LVDT in one of the measuring points along the chord direction.
c) Application of the force in the first point by means of the screw device (loading from zero up to a value adequate to measure the force-displacement curve on video), then unloading, then repeating the loading-unloading cycle at least 2-3 times
d) Recording of the displacement values in at least two positions along the chord (w1 and w2) and evaluation of the value of the rotation or delta displacement.
e) Movement of the force application point by repeating step d) and tracing the position of the force-rotation graph (see figure 6)

1.2. Materials provided for the experiment

The materials and tools provided are as follows (Fig. 3):

- Aluminum beam, section to measure
- Loading frame with supports, screw loading device, load-cell (AEP model TCA , 500 N force range), LVDT (AML/EU/±5/S, ±5 mm stroke range) and sliding support for its positioning
- Connecting cables with plugs
- Regulated stabilized laboratory power supply (ISO-TECH IPS303DD, Vout 0 → 30 V)
- Two-channels, USB data acquisition board with A/D conversion NI 9218 (in chassis cDAQ-9171, CompactDAQ, 1 slot, USB connected)
- Personal computer (PC) with dedicated data acquisition software (developed in the NI LabView® environment)

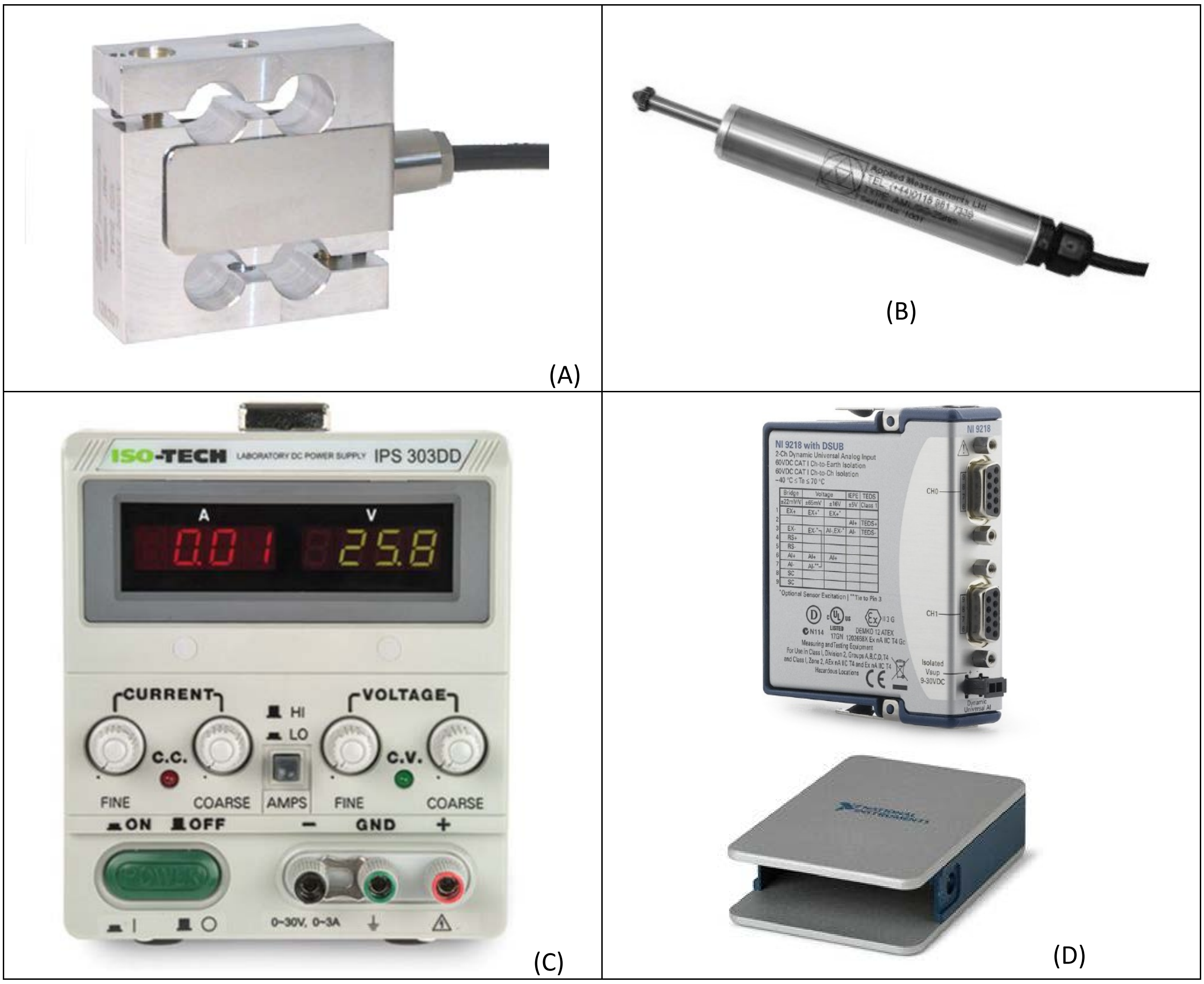


Fig. 3 – Equipment for the experiment: (A) load-cell AEP model TCA; (B) LVDT; (C) power supply ISO-TECH IPS303DD; (D) Data acquisition board NI 9218 and chassis cDAQ-9171 (CompactDAQ)

2. Operation

First of all it is necessary to power on the PC and all the required electronic equipment. After that a login to the PC is required by using each own personal credentials of the Educational Portal (https://login.didattica.polito.it/secure/ShibLogin.php).

1. Switch the power supply on and set the output to a value slightly greater than 12 V (tentatively within 13 V and 15 V) using the knobs VOLTAGE (Fig. 2(C); if voltage read on the display on the right does not increase, raise the current limit with the knobs CURRENT)
2. Check connections or connect the power cables of the LVDT (from the power supply to the CompactDAQ) by respecting the red/black colors (the red plug shall be inserted in the red outlet, the black plug into the black outlet)Verificare il collegamento dell’LVDT al sistema di acquisizione CompactDAQ (*)
3. Check the connection of the LVDT to the CompactDAQ acquisition board (*)Verificare il collegamento del sistema di acquisizione CompactDAQ al PC (*)
4. Check the connection of the load cell to the CompactDAQ acquisition board (*)
5. Check the connection of the CompactDAQ acquisition board to the PC (*)

6. Place the beam on the supports and connect (mechanically) the loading device to the beam (if not already mounted)
7. Activate the acquisition program (Fig. 4)

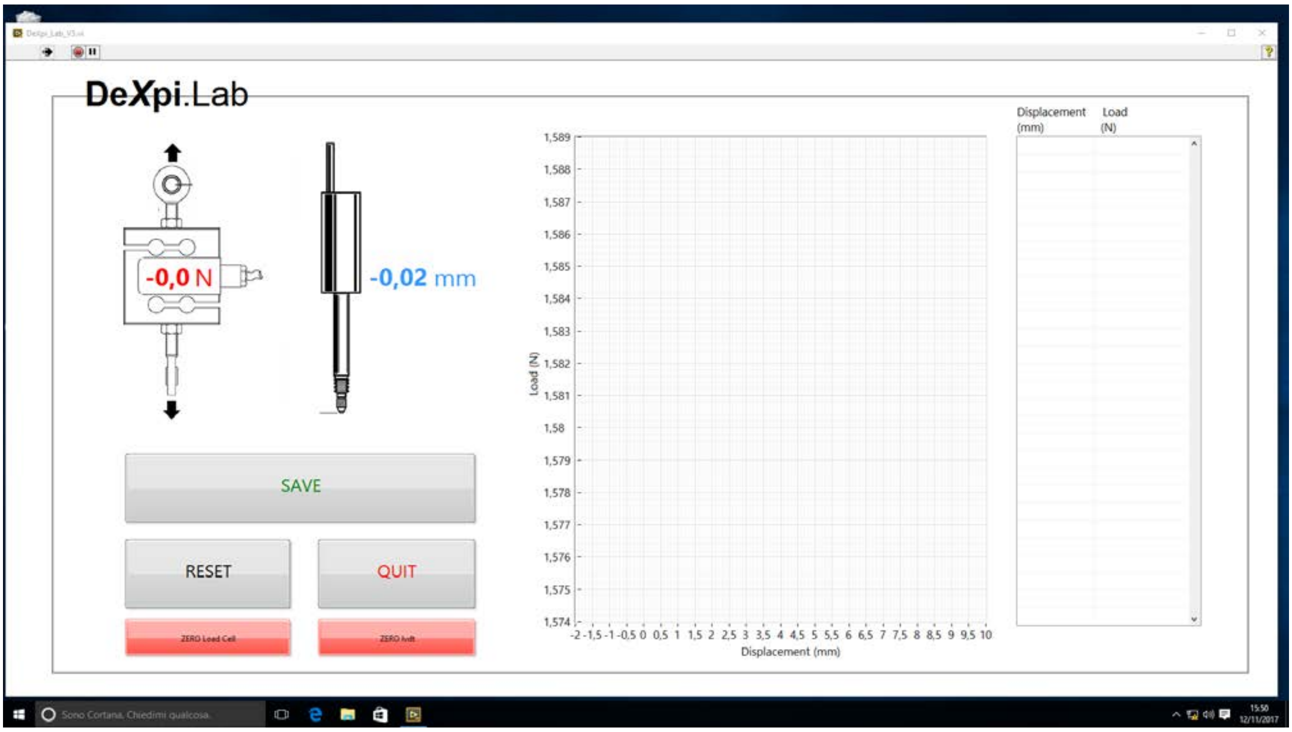


Fig. 4 – Screenshot of the acquisition software

8. Position the sliding support in the first position for the measure, at mid-span
9. Place the spherical joint that connects the load cell to the beam and then determine the point of application of the force, at the vertical wall of the beam section.Dare avvio all'acquisizione con il programma.
10. Start the acquisition with the program.
11. Reset the reading of the load cell and the LVDT through the appropriate red buttonsi ZERO lvdt and

    ZERO Load Cell

    WARNING: if it is necessary to reset, close the measurement program and restart it before reset

12. Apply a preload of 20 N
13. Start the test by loading and unloading the beam (at least 3 times checking the repeatability on the graph displayed by the acquisition program)
14. Perform the measurements according to this procedure:
    14.1. Record the deflection value at position w1 by reading it on the screen and returning it to a table (on paper or in electronic format) or storing the values from the program (Figure 6) by pressing the key SAVE
    14.2. Repeat procedure 14.1 for the second chord measurement point (w2)
15. Repeat the test by changing the position of the force application point, adjusting the position of the nuts that fix the position of the ball joint.
16. For each force application point, record the two displacement values w1 and w2 along the chord in order to calculate the rotation of the section.

As a measure of the position of the force application point, measure the distance between the fixed and mobile nuts indicated in Figure 5.

Figura 5: misura della posizione del punto di applicazione della forza

17. Once the test finished leave everything in place: the laboratory assistants will then check and dismount the equipment if necessary.

(*)in case of problems do contact the laboratory assistants

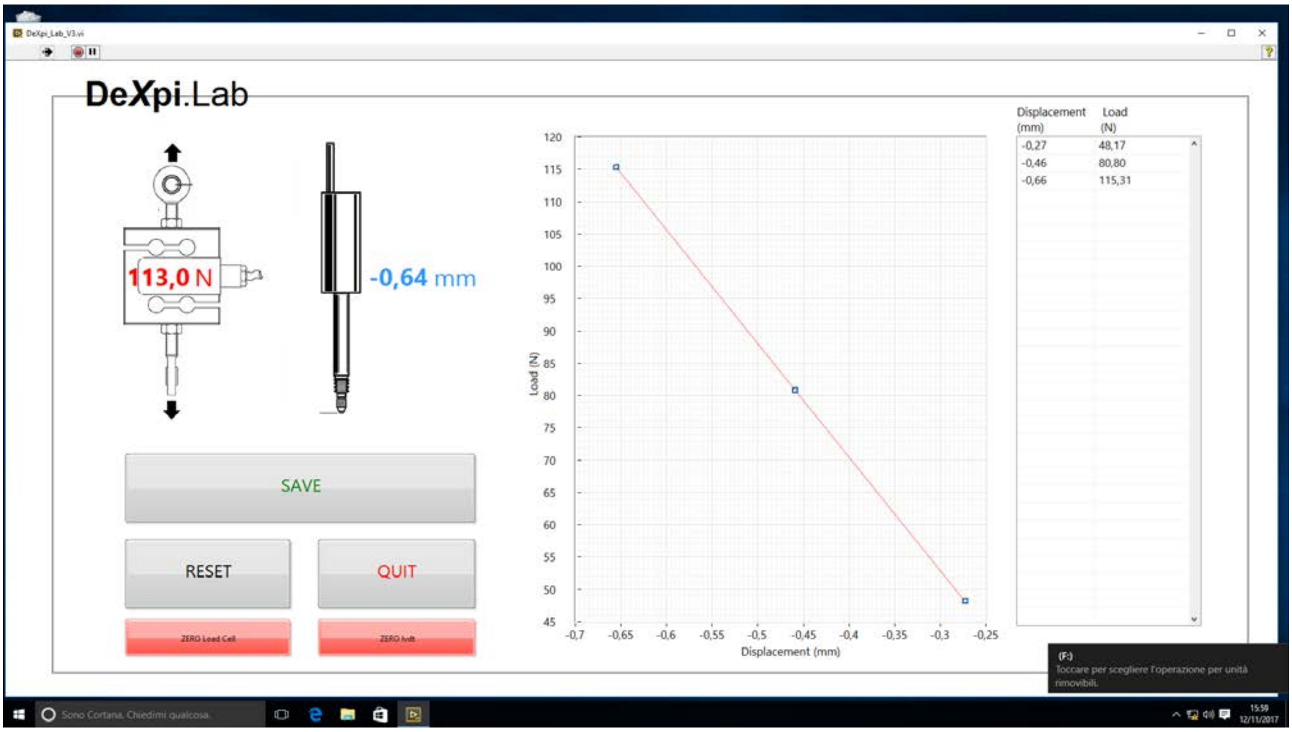


Fig. 6 – Exporting the measurements

2.1. Elaboration and presentation of results

It is requested to determine the graph of the position of the force according to the rotation of the section using the measurements made previously. A graph of the type indicated in Figure 6 is obtained from which it is possible to evaluate the point at which the two displacement measurements carried out coincide. This particular position of the force application point coincides with the cutting center of the section. Finally, we ask to compare the value obtained with that calculated theoretically.

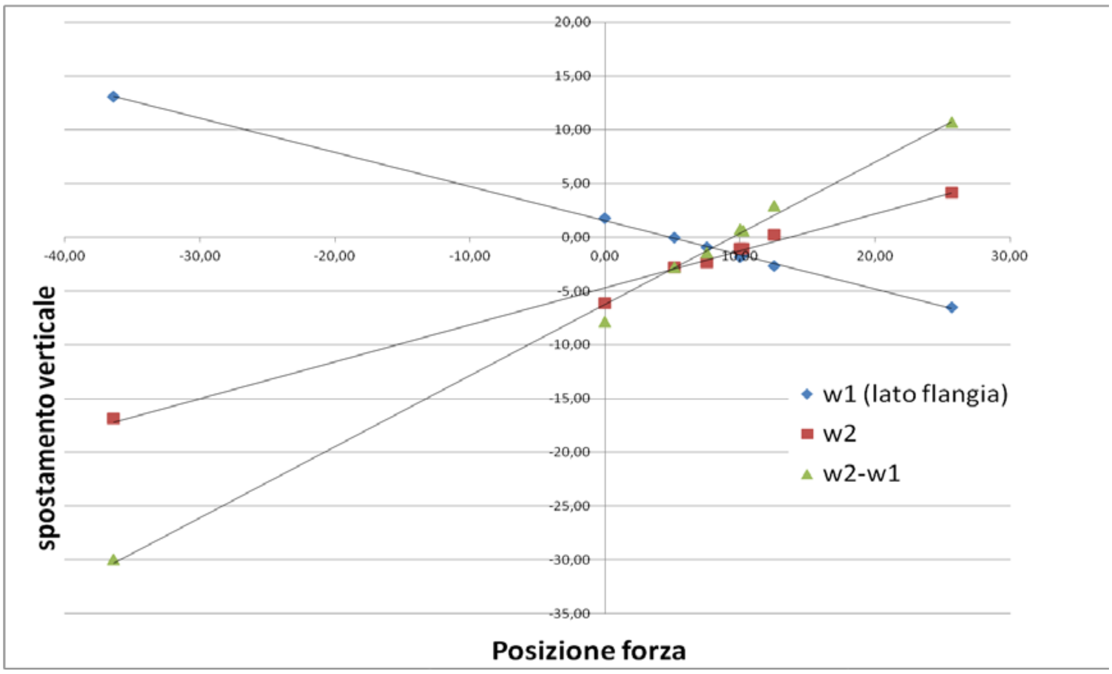


Fig. 6 – Grafico posizione forza - spostamento verticale

3. Check of the experimental results

Verification of the accomplished experiment and of the correctly collected data will be done through the generation of an automated report through a form in each own personal page of the educational portal.

Attached, a facsimile (Appendix B) of the reporting scheme as it will be found.

4. Appendix B
Form for the experimental test reporting

Course: Aeronautical Constructions

Topic: Determination of the shear center position for an open section thin walled beam

Description of the experiment (mandatory field, 500 characters minimum)

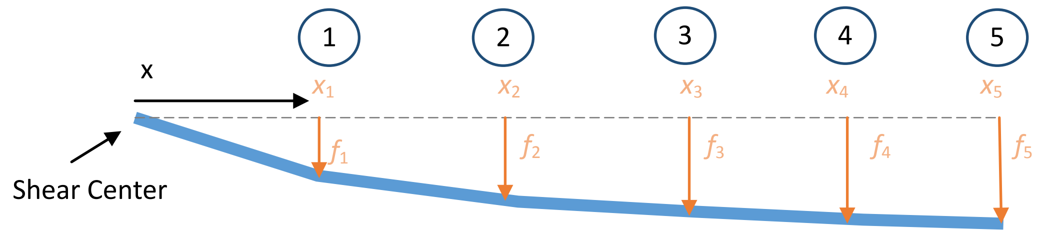
Description of the procedure (mandatory field, 500 characters minimum)

Description of the used materials, tools and devices (mandatory field, 200 characters minimum)

Rilevazioni (campi obbligatori, con verifica automatica del risultato)

Point No.	1	2	3	4	5
Force position in chord, *x*(mm)	x_1	x_2	x_3	x_4	x_5
DeltaW=f (mm)	f_1	f_2	f_3	f_4	f_5

Difference between w1 and w2 displacements measurements



Nota:

- Measures are in millimiters

Results analysis and conclusions (mandatory field, 300 characters minimum)

Comments (optional field, 1000 characters maximum)