Virtual Laboratory Experiment

Lecturer responsible: Charles Loo

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Weight: 10% of final mark

1 Experiments

The following are three experiments that can be conducted in the laboratory:

A. Roof truss
B. Bending moment in a beam
C. Shear force in a beam

Some of the experiments have to be conducted in both of the following two ways:

1. Virtual experiment (in computer lab using TecQuipment software)

   For those Offsite: Please use Dr. Frame

2. Practical experiment (in laboratory EB380 using TecQuipment hardware)
   For those Offsite: Please use data provided to you.

Some of the experiments only have to be conducted as virtual experiments.

For those experiments which have to be conducted both virtually and practically, only the practical experiments will be described here. You have to conduct exactly the same experiments on the computer and compare the results with the practical experiments. Some limits exist for the applied loads on the hardware. Therefore, conduct the virtual experiments first and check that your loading is within the allowed limits for the hardware.

Finally, you have to write up a report based on your experiments. Section 2 contains a possible layout of your report. You will only have to report on one of the three experiments. After you have completed the practical laboratory experiments, you will be told which experiment you have to write a report about.

1.1 Roof truss

1.1.1 Introduction

The practical experiment is conducted in a desk mounted testing frame as shown in Fig. 1.

The load is applied at the node at the centre of the bottom chord of the truss. A load may be applied in the up-ward or in the down-ward vertical direction. The applied load is displayed in the load display.

Strain gauges are attached to all truss members. The strain gauges are used for measuring the strains in the members. The strains are displayed in the display on the strain display box (displayed as $10^{-6}\varepsilon$). However, notice that the strain display box does NOT allow for the strains to be initialized. You therefore need to do two readings of the strains for every load: First you read the strain for zero load applied, ε_0. Then you apply the load and read the strain, ε_1. The strain due to the applied load is taken as $\varepsilon = \varepsilon_1 - \varepsilon_0$.

The truss members are made of stainless steel with modulus of elasticity (MOE) E = 210000 MPa. All members have solid circular cross sections with a nominal diameter d = 6 mm.

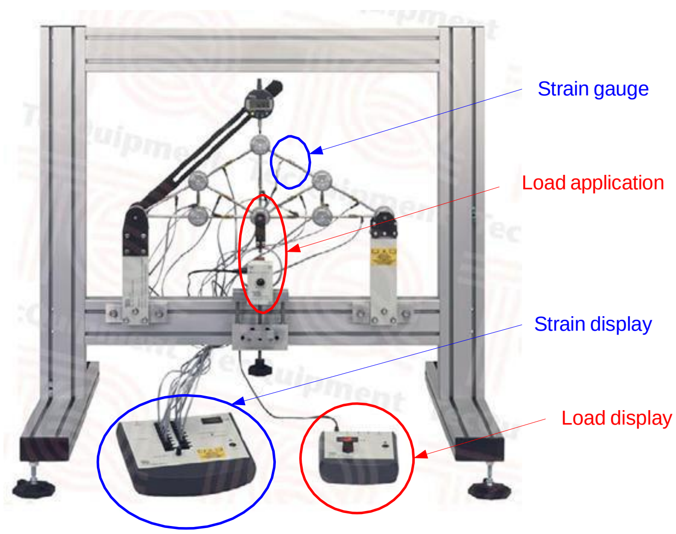

Fig. 1 Testing frame for measuring member forces in a roof truss

1.1.2 Testing schedule

The following loads, *P*, have to be applied and the corresponding values of the strains in all members have to be measured: *P* = -100 N, -200 N, -400 N, 0 N, 100 N, 200 N, 400 N.
The experiment has to be conducted on the computer as well as in the testing frame, and the results have to be compared. Print out the results of the virtual experiments (you will need it for your report).

In addition to the experiment given above, the following virtual experiment should be conducted on the computer: (1) Change the diameter of the truss members to 5 mm and apply a load of *P* = 200 N. (2) Use again a diameter of 6 mm, but change the modulus of elasticity and apply a load of *P* = 200 N (you choose the MOE yourself). Print out the results of the virtual experiments (you will need it for your report).

1.1.3 Discussion of results

Compare your virtual laboratory results and the measured results.

For each of the loads *P* = -200 N and *P* = 200 N, make a drawing of the truss showing which members are in compression (red colour), which are in tension (blue colour) and which carry no force (black).

Comment on the results (e.g.: Is the structure linear? If it is, what are the implications? Are there differences between the measured and the calculated forces? If so, is there a systematic difference? If there is a systematic difference, try to explain what could possibly cause the difference. What influence does the diameter of the truss members have on the forces? What influence does the MOE of the truss members have on the forces?).

1.2 Bending moment in a beam

1.2.1 Introduction

The practical experiment is conducted in a desk mounted testing frame as shown in Fig. 2.

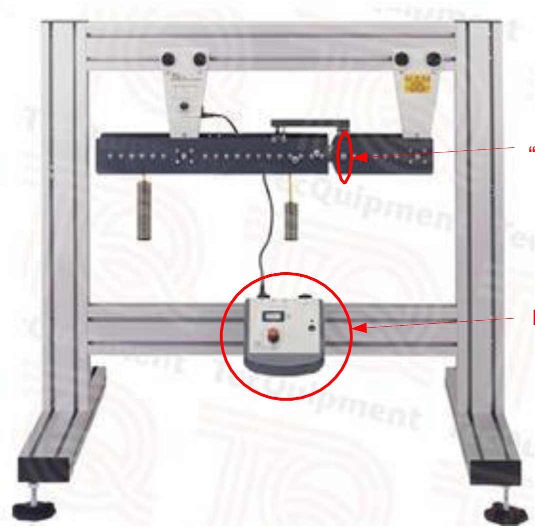

Fig. 2 Testing frame for measuring the bending moment in a beam

1.2.2 Testing schedule

Three separate experiments, I, II, and III have to be conducted.

Experiments I and II:
In general two masses, m_0 and m_1, have to be applied to the beam. The mass m_0 must be applied at the "cut" position (i.e. at x = 440 mm) as shown in Figs. 2 and 3. The position of mass m_1 is chosen by the team, but it should not be placed too close to the left support or to the mass m_0, and it must be placed to the left of mass m_0. Experiments I and II are conducted both as virtual experiments and practical experiments. **Do the virtual experiments first and check that the applied loads make the moment at the "cut" position fall within the range [- 0.625 Nm ; +1.0 Nm] since the hardware is limited to this range**.

The following masses have to be applied and the corresponding values of the moment at the "cut" position measured:

I: m_0 = 0, 100g, 200g, 300g, 400g and m_1 = 0 (In total 5×1 = 5 measurements)

II:								
m_0 [g]:	0	0	200	200	200	400	400	400
m_1 [g]:	200	400	0	200	400	0	200	400

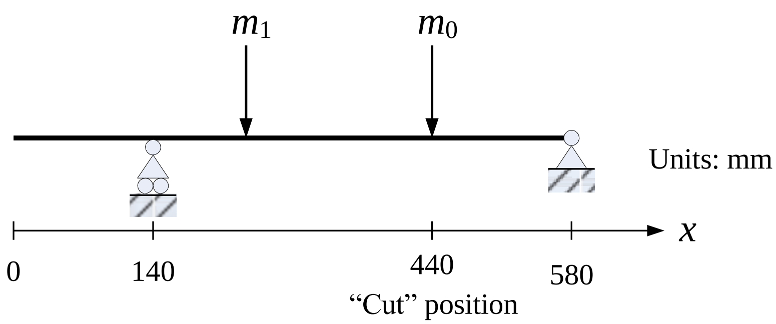

Fig. 3 Geometry of test set-up for determination of the bending moment in a beam

Experiment III:

This experiment should only be conducted as a virtual experiment. Determine the moment diagrams for the load combinations shown in Fig. 4.

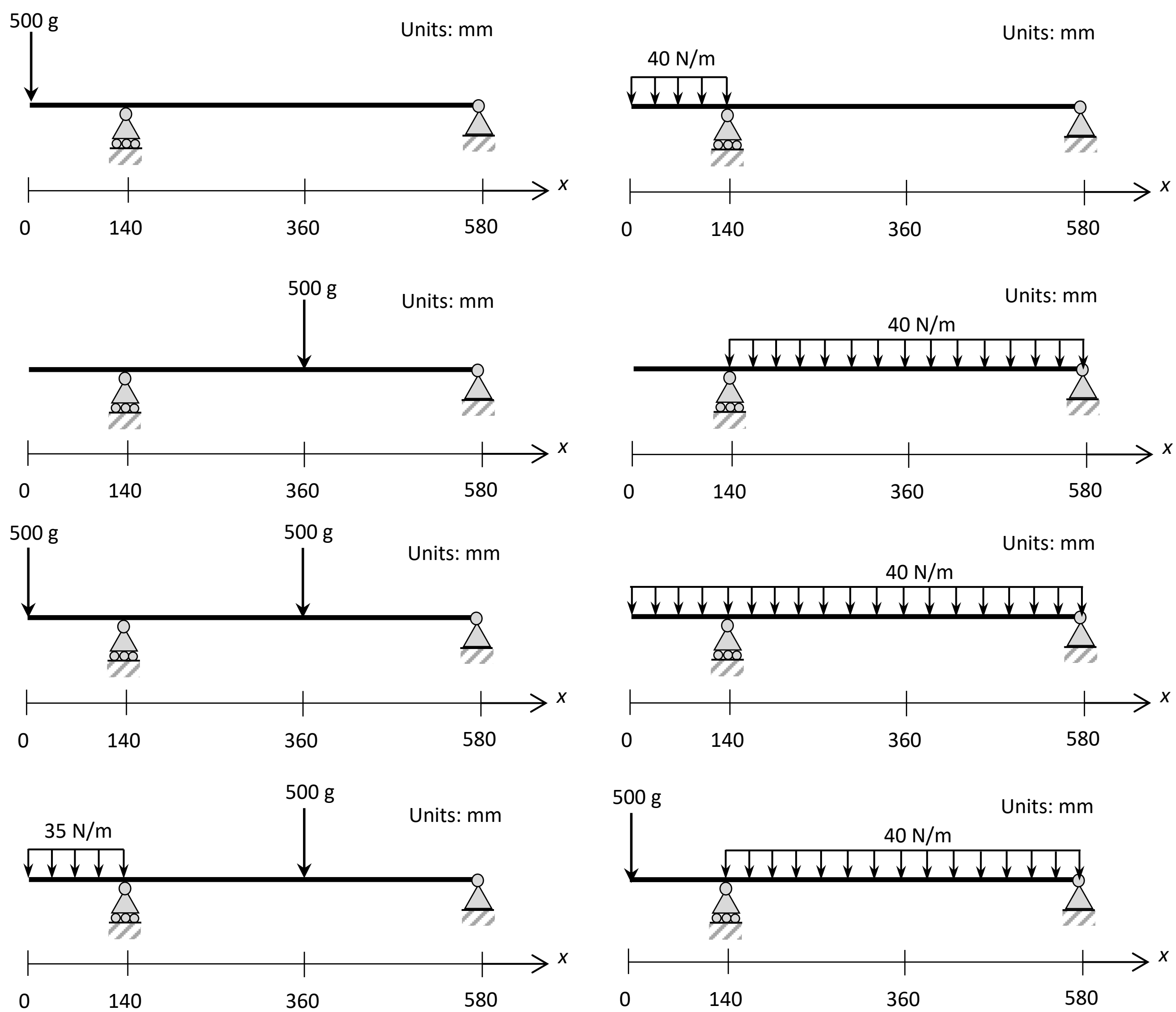

Fig. 4 Load combinations involving concentrated loads and uniformly distributed loads

1.2.3 Discussion of results

For Experiment I:

- Include figures showing the theoretical moment diagrams (i.e. the moment diagrams determined in the virtual experiment) for the applied masses m_0 = 100 g and m_0 = 400 g.
- Make a graph showing the moment at the "cut" position as a function of the applied loads. Show the theoretical and the measured moments in the same graph. Show the theoretical moments as a line and the measured moments using marker points. Comment on the results (e.g.: Is the structure linear? If so, what are the implications? Compare the theoretical moments with the measured moments. Are the theoretical moments in agreement with the measured ones?)

For Experiment II:

- Include figures showing the theoretical moment diagrams for all the considered load combinations. Comment on the diagrams.
- Include tables showing the theoretical and measured values of the moment at the "cut" position for the different load combinations. Compare theoretical and measured values of the moments. Comment on the results.

For Experiment III:

- Include figures showing the theoretical moment diagrams for all the considered load combinations. Comment on the results.

1.3 Shear force in a beam

1.3.1 Introduction

The practical experiment is conducted in a desk mounted testing frame as shown in Fig. 5.

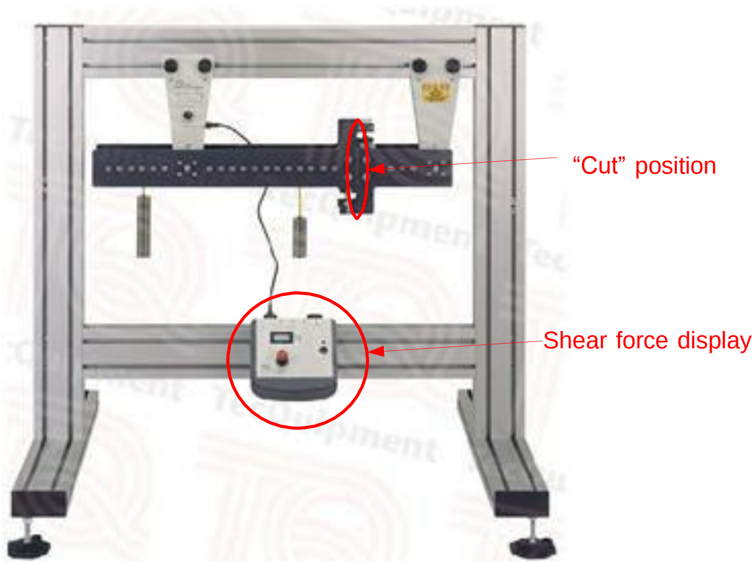

Fig. 5 Testing frame for measuring the shear force in a beam

1.3.2 Testing schedule

Three separate experiments, I, II and III, have to be conducted.

Experiments I and II:
In general, two masses, m_0 and m_1, have to be applied to the beam. The mass m_0 must be applied 40 mm to the left of the "cut" position (i.e. at x = 400 mm) as shown in Fig 6. The position of mass m_1 is chosen by the team, but it should not be placed too close to the left support or to the mass m_0, and it must be placed to the left of mass m_0. Experiments I and II are conducted both as virtual experiments and practical experiments. **Do the virtual experiments first and check that the applied loads make the shear force at the "cut" position fall within the range [± 5.0 N] since the hardware is limited to this range**.

The following masses have to be applied and the corresponding values of the moment at the "cut" position measured:

I: m_0 = 0, 100g, 200g, 300g, 400g and m_1 = 0 (In total 5×1 = 5 measurements)

II:

m_0 [g]:	0	0	200	200	200	400	400	400
m_1 [g]:	200	400	0	200	400	0	200	400

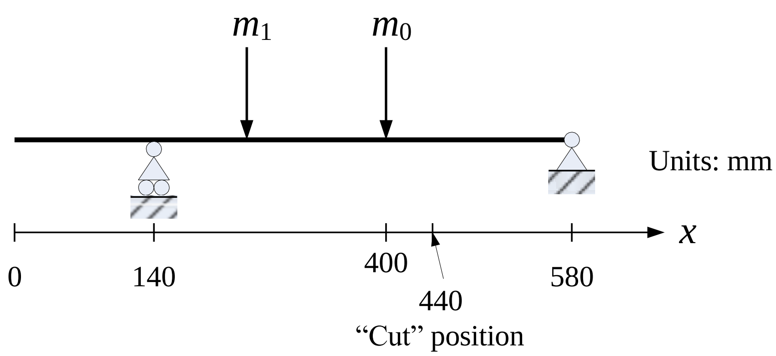

Fig. 6 Geometry of test set-up for determination of the shear force in a beam

<u>Experiment III</u>:
This experiment should only be conducted as a virtual experiment. Determine the shear force diagrams for the load combinations shown in Fig. 4.

1.3.3 Discussion of results

For Experiment I:

- Include figures showing the theoretical shear force diagrams (i.e. the shear force diagrams determined in the virtual experiment) for the applied masses m_0 = 100 g and m_0 = 400 g.
- Make a graph showing the shear force at the "cut" position as a function of the applied loads. Show the theoretical and the measured shear forces in the same graph. Show the theoretical shear forces as a line and the measured shear forces using marker points. Comment on the results.

For Experiment II:

- Include figures showing the theoretical shear force diagrams for all the considered load combinations. Comment on the diagrams.
- Include tables showing the theoretical and measured values of the shear forces at the “cut” position for the different load combinations. Compare theoretical and measured values of the shear forces. Comment on the results.

For Experiment III:

- Include figures showing the theoretical shear force diagrams for all the considered load combinations. Comment on the results.

2 Report

Each student has to write a report.

The report must as the first two pages contain the

- Coursework Cover Sheet
- Coursework Assessment Sheet (uploaded on ICE)

and may then contain

Contents

List of contents

Notation

List all variables used in equations and explain their meanings. Instead of a list of variables here, you can also explain the variables in the text at first appearance (e.g. after an equation, you can write ….” … where *E* is the modulus of elasticity and *A* is the cross section area of the truss member.”

1 Introduction

Give the reader a brief introduction. Explain that this report is written in partial fulfilment of the requirements for passing CEN103. Explain that you conducted three practical and virtual experiments on a roof truss and on beams determining bending moments and shear forces, and that your report is limited to describing only one of the experiments (selected at random by the lecturer of CEN103) .

2 Theory

Try here to describe the relevant parts of the theory which is involved in the experiment you have to write about. When you use equations, each equation should be given a number in brackets (e.g. (3)) placed close to the right margin. Refer to an equation by e.g. “The axial strain, ε, is given by Eq. (3).”

Roof Truss

Give here the equations needed for calculating the force in a member from the measured strain. i.e. the normal stress as a function of the force and the cross section area, Hooke’s Law etc.

Bending moment in a beam
Give here the equations needed for calculation of the moment in the considered beam.

Shear force in a beam
Give here the equations needed for calculation of the shear force in the considered beam.

3 Experiments

3.1 Methods (and materials)

Roof Truss
Describe the experiments conducted. Also give the necessary information on the truss member dimensions and material properties.

Bending moment in a beam
Describe the experiments. (No materials used here).

Shear force in a beam
Describe the experiments. (No materials used here).

3.2 Results

Roof Truss, Bending moment in a beam, and Shear force in a beam
Present the results.

4 Discussion

Roof Truss, Bending moment in a beam, and Shear force in a beam
Discuss the results

5 Conclusions

Conclude on your findings (comparison between measured values and calculates values, linearity, superposition).