Lab Experiment

Beam Bending

Jiaqi, Yao.*

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Section A

In this section, the Young's modulus of two materials (mild steel and aluminium) can be calculated from experimental data.

A total of six groups of data were obtained from the experiment. (See Table 1)

Analysis

By plotting these 6 groups of data on a scatter plot and performing regression analysis, a total of 6 groups of graphs were obtained. (See Figure 1)

No.	Material	Final load (N)	K(Slope)	R-square
1	Steel	50	370.4	0.9999
2	Steel	100	379.1	0.9998
3	Steel	150	369.4	0.9989
4	Aluminium	50	138.9	0.9999
5	Aluminium	100	139.4	0.9999
6	Aluminium	150	134.8	0.9987

(Notice: The unit of K is N/mm, it needs to multiply 10^3 to transfer to N/m)

Table 1: result of A1 regression analysis
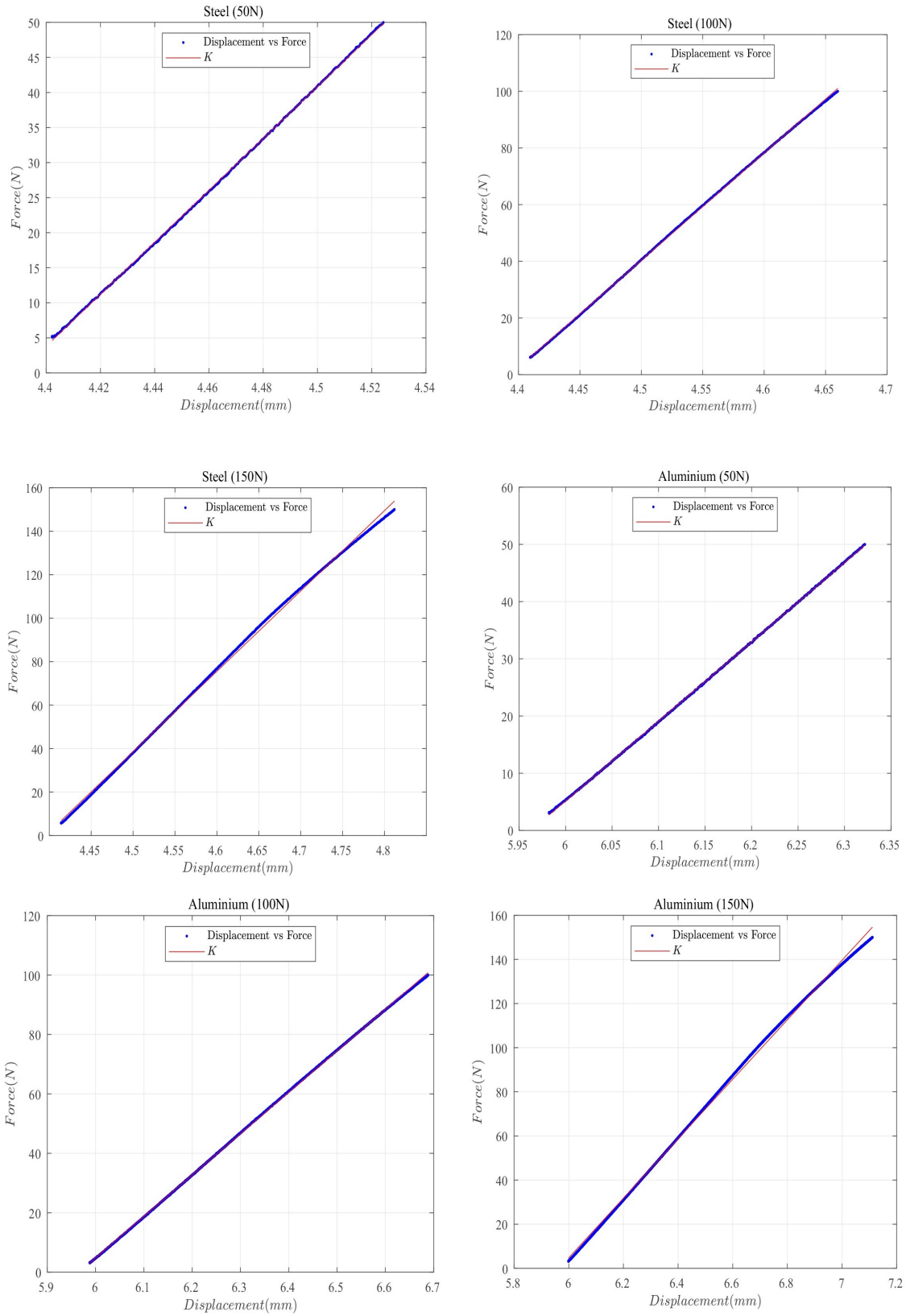
*jy431@exeter.ac.uk

Figure 1: This is an inserted JPG graphic

In order to calculate E, the moment of inertia I needs to be calculated first.

$$I = \frac{bh^3}{12} = \frac{20 * 3^3}{12} * 10^{-12} = 4.5 * 10^{-11}(mm^4) \tag{1}$$

We know

$$\delta_{max} = \frac{PL^3}{48EI} \tag{2}$$

And the slope of the regression analysis is

$$K = \frac{P}{\delta} = \frac{48EI}{L^3} \tag{3}$$

So

$$E = \left(\frac{P}{\delta}\right) * \frac{L^3}{48I} = K * \frac{L^3}{48I} \tag{4}$$

Calculate each group of data and obtain the table 2.

Modulus of Elasticity	Mild Steel	Aluminium
$E_1(P = 50N)$	171.482	64.3056
$E_2(P = 100N)$	175.509	64.5370
$E_3(P = 150N)$	171.019	62.4074
$E_{exp} = (E_1 + E_2 + E_3)/3$	172.670	63.75
(Unit: GPa)		

Table 2: result of A1 regression analysis

Summary

As can be seen from the data in Table 2, the modulus of elasticity of mild steel (172.67GPa) is much larger than aluminium (63.75GPa). In addition, due to the difference in modulus of elasticity, the deformation of aluminium is greater than that of mild steel under the same force.

The comparison for each material indicates that there is a slight difference in the modulus of elasticity, which may be due to experimental error, and the more accurate modulus of elasticity can be obtained through more experiments.

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Section B

In this section, the deformation of each material under different forces can be calculated from the data obtained in section A.

Analysis

We know

$$\delta_{max} = \frac{PL^3}{48EI} = \frac{P * 0.1^3}{48 * E_{exp} * 4.5 * 10^{-11}} \tag{5}$$

Using the E_{exp} in different material(Mild Steel and Aluminium) with different force(50N, 100N, 150N) in Table 2, the data in Table 3 can be calculated.

Bending Displacement	Mild Steel	Aluminium
$\delta_{AN\_1}(P = 50N)$	0.1341	0.3631
$\delta_{AN\_2}(P = 100N)$	0.2681	0.7262
$\delta_{AN\_3}(P = 150N)$	0.4022	1.0893

(Unit: GPa)

Table 3: result of A1 regression analysis

Summary

Bringing the average modulus of elasticity into the equation enables a more accurate calculation of the deformation of the material under different forces and helps to reduce experimental errors.

Section C

In this section, finite element analysis (ANSYS) is performed on the components.

Analysis

ANSYS analysis results are shown in Figure 2.

The finite element analysis in Figure 2 gives the deformation-position curves for different materials under different forces, where the maximum deformation of the component can be easily determined.
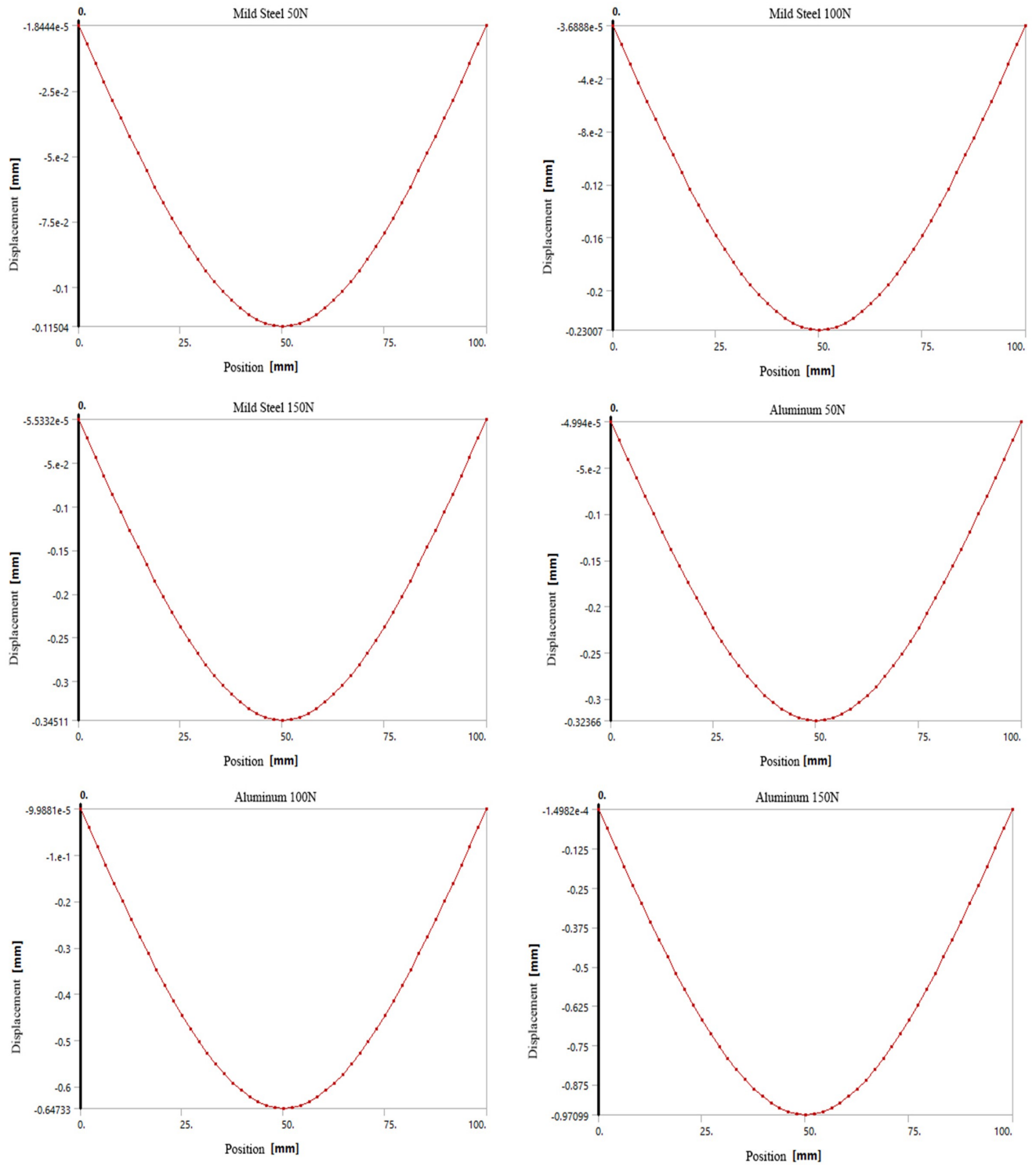
Figure 2: This is an inserted JPG graphic

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The data are shown in Table 4.

Bending Displacement	Mild Steel	Aluminium
$\delta_{FE\_1}(P = 50N)$	0.1150	0.3237
$\delta_{FE\_2}(P = 100N)$	0.2300	0.6473
$\delta_{FE\_3}(P = 150N)$	0.3451	0.9710

(Unit: GPa)

Table 4: result of A1 regression analysis

Summary

By using ANSYS analysis, deformation-displacement diagrams were obtained for two materials under three different forces, revealing that the maximum deformation exists at the midpoint of the element (the point where the forces are applied).

Section D

Analysis

Summarise

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