PDES1195

Engineering Analysis Individual lab report:

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Equipement, method, results, discussion, Conclusion

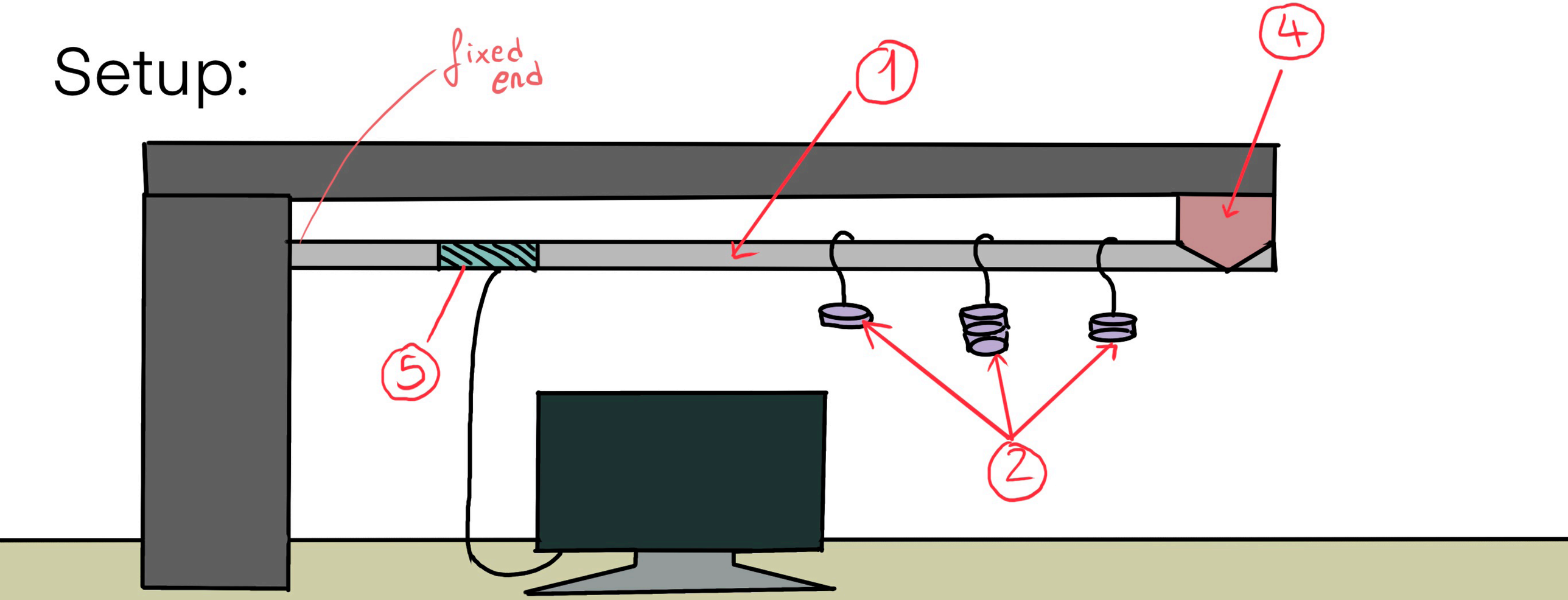
Equipment

List:

1. Cantilevered steel beam
2. 50g Weights and hanger
3. 30cm ruler
4. Digital displacement transducer
5. Strain gauge meter

The Cantilevered beam is vertically fixed at one end and freely hanging at the other.
The 50g weights can be stacked on the hangers.
The displacement transducer is attached to the vertical support and at the freely hanging end of the cantilevered beam. The strain gauge meter is composed of 4 strain gauges attached to both surfaces of the beam (average distance of 18.5mm from fixed support) and connected to Wheatstone bridge circuit

Setup:



Method

Experiment 1:
50g weights were incrementally added to the free end of the beam.
During each load increment:
- the displacement of the beam (v) was recorded using the digital displacement transducer reading.
- The strain was recorded using the strain gauge meter reading.

The 30cm ruler was used to measure the distance of the hanging weights from the Fixed support.

Experiment 2-A:
This time 3 different Loads (M1, M2 and M3) were individually added to 3 different Points (A, B and C) along the cantilever beam.
Similarly to expirement 1: the Displacement and the strain is recorded for each load (M1, M2 and M3) at each Point (A, B and C). The 30cm ruler was used to measure the distance of each Point (A, B and C) from the Fixed support.

Experiment 2-B:
The same 3 loads (M1, M2 and M3) were randomly and simultaneously placed on the same 3 points (A, B and C). This is repeated to get 4 different combinations. The displacement and strain is again recorded for each combination.

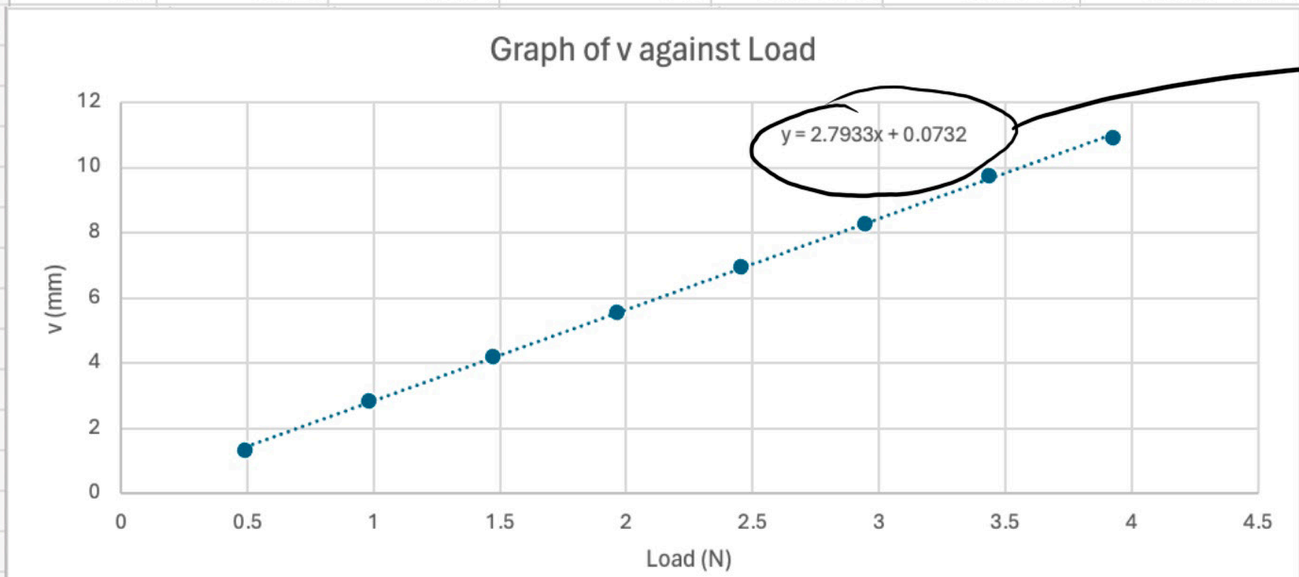
Results

→ Second Moment of Area : $\frac{24.93 \times 3.04^3}{12} = 58.36625 \text{ mm}^4$

Mass (g)	Load (N)	v (mm)	Microstrain	Strain	M (N mm)	Stress (Mpa)
50	0.4905	1.34	20	0.00002	216.55575	5.639641745
100	0.981	2.86	38	0.000038	433.1115	11.27928349
150	1.4715	4.21	57	0.000057	649.66725	16.91892524
200	1.962	5.58	76	0.000076	866.223	22.55856698
250	2.4525	6.96	95	0.000095	1082.77875	28.19820873
300	2.943	8.3	113	0.000113	1299.3345	33.83785047
350	3.4335	9.75	133	0.000133	1515.89025	39.47749222
400	3.924	10.91	149	0.000149	1732.446	45.11713396

$$\sigma = \frac{My}{I} \Rightarrow \frac{M\left(\frac{d}{2}\right)}{I}$$

$(d = 3.04)$



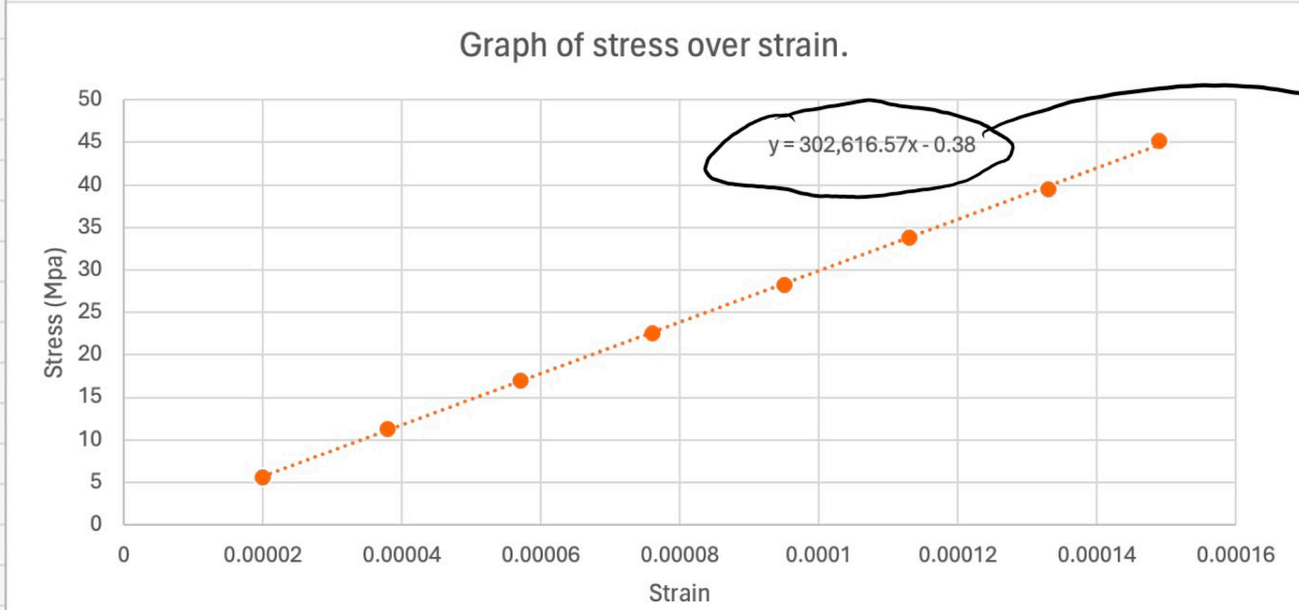
gradient is 2.7933

$$E = \frac{1}{\text{gradient}} \times \frac{L^3}{3I}$$

$$E = \frac{1}{2.7933} \times \frac{460^3}{3 \times 58.4} = 199009.07$$

MPa

$\Rightarrow$ 199.01 GPa



Gradient is 302 617 MPa

which is approximately

equal to 303 GPa

Results

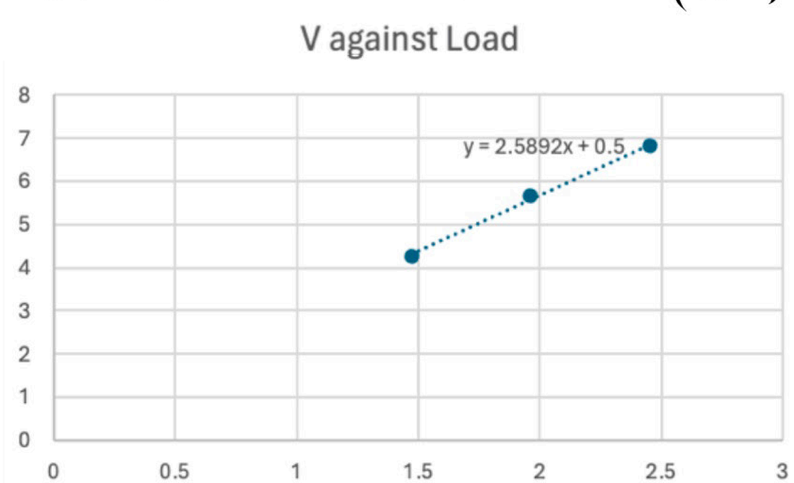
(Part 2-A)

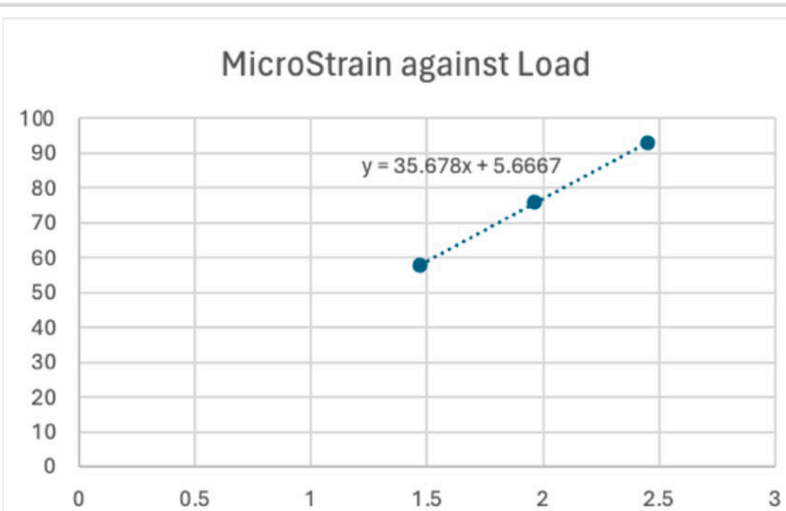
K	L	M	N	O	P	Q	R	S
Point A		Point B		Point C		v (mm)	Microstrain	Strain
Mass (g)	Load (N)	Mass (g)	Load (N)	Mass (g)	Load (N)			
150	1.4715					4.27	58	0.000058
250	2.4525					6.81	93	0.000093
200	1.962					5.66	76	0.000076
		150	1.4715			2.62	41	0.000041
		250	2.4525			4.13	65	0.000065
		200	1.962			3.55	53	0.000053
				150	1.4715	0.92	21	0.000021
				250	2.4525	1.31	32	0.000032
				200	1.962	1.01	26	0.000026

Point A

deflection per unit load: 2.59 (mm/N)

Strain per unit load: 35.7×10^{-6} (N^{-1})

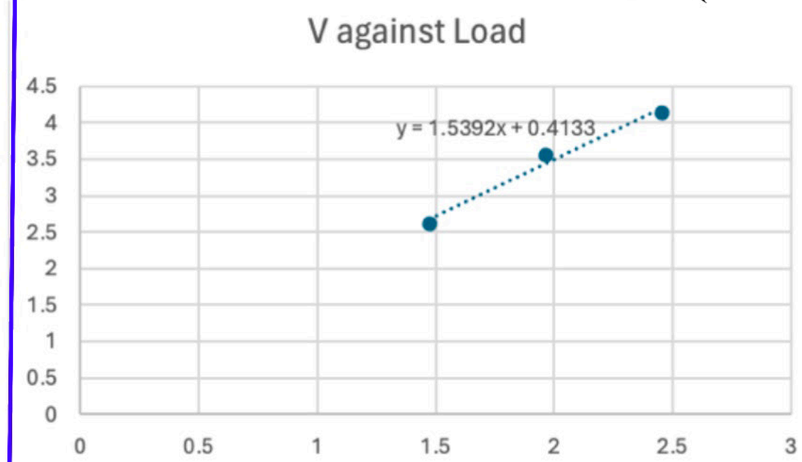


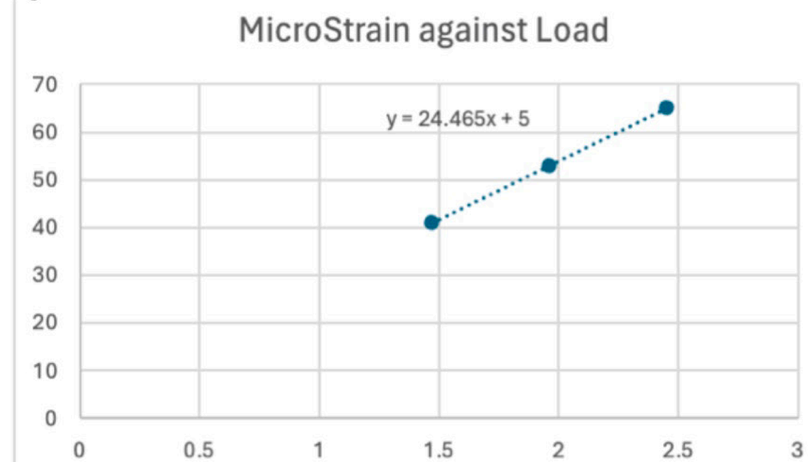


Point B

deflection per unit load: 1.54 (mm/N)

Strain per unit load: 24.5×10^{-6} (N^{-1})

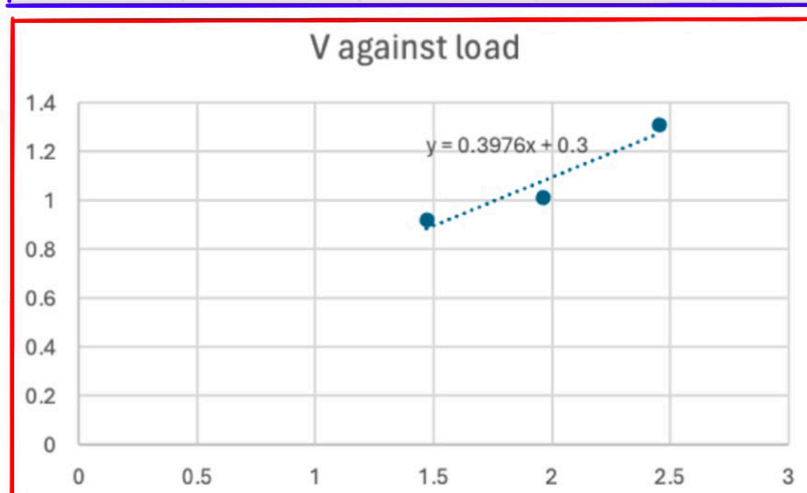


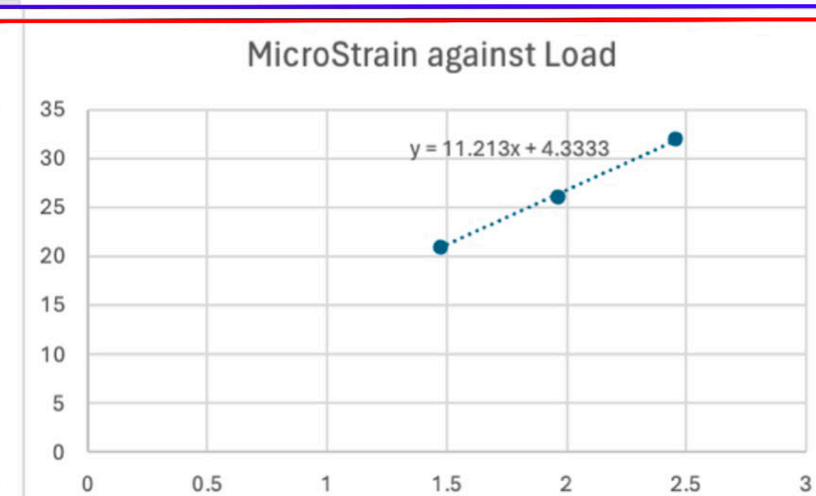


Point C

deflection per unit load: 0.400 (mm/N)

Strain per unit load: 11.2×10^{-6} (N^{-1})





Results

(Part 2-B)

① $V_{ps} = 4.27 + 3.35 + 1.31 = 9.13$

$S_{ps} = (58 + 53 + 32) \times 10^{-6} = 0.000143$

② $V_{ps} = 4.27 + 4.13 + 1.01 = 9.41$

$S_{ps} = (58 + 65 + 26) \times 10^{-6} = 0.000149$

③ $V_{ps} = 6.81 + 2.62 + 1.01 = 10.44$

$S_{ps} = (93 + 41 + 26) \times 10^{-6} = 0.000160$

④ $V_{ps} = 5.66 + 4.13 + 0.92 = 10.71$

$S_{ps} = (76 + 65 + 21) \times 10^{-6} = 0.000162$

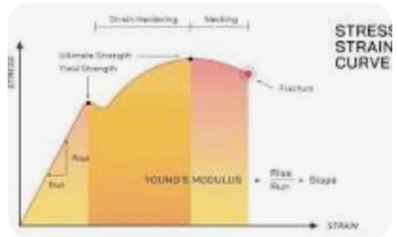
	Point	Mass (g)	Load (N)	v (mm)	Vps (mm)	Microstrain	Strain	Sps
1	A	150	1.4715	9.05	9.13	148	0.000148	
	B	200	1.962					
	C	250	2.4525					0.000143
2	A	150	1.4715	9.64	9.41	155	0.000155	
	B	250	2.4525					
	C	200	1.962					0.000149
3	A	250	2.4525	10.68	10.44	165	0.000165	
	B	150	1.4715					
	C	200	1.962					0.00016
4	A	200	1.962	9.96	10.71	154	0.000154	
	B	250	2.4525					
	C	150	1.4715					0.000162

Discussion: experiment 1

About 13,700,000 results (0.25 seconds)

between 190 and 215 GPa

The Young's modulus of steel usually falls between 190 and 215 GPa. This value represents the material's stiffness or ability to resist deformation when subjected to tensile or compressive forces. It is a measure of the material's elasticity, indicating how much it will stretch or compress under stress. 18 Aug 2023



The expected value for steel is around 200 GPa

(Temperature and pressure in the lab can also have an effect on the Young's modulus values but would be negligeable)

Method 1:

The calculated Young's modulus in Method 1 was 199 GPa. This is therefore a great value as it falls between the range of 190 to 215 GPA

Method 2:

Method 2, which involved plotting a graph of Stress over strain, gave a Young's modulus value of 303 GPa, which is significantly higher than expected. I believe this error originates from the calibration of the Strain gauge meter. My reason for believing this; is because the graph of stress over strain is a positive straight line, which indicates the experiment was correctly conducted but that there is a systematic error in the values which is causing the gradient to be higher than expected.

Discussion: experiment 2

v (mm)	Vps (mm)
9.05	9.13
9.64	9.41
10.68	10.44
9.96	10.71

Both Displacement values (V and Vps) are very similar

Equally, both Strain values (strain and Sps) are very similar.

this validates the principle of superposition to a relatively precise level of accuracy.

Strain	Sps
0.000148	0.000143
0.000155	0.000149
0.000165	0.00016
0.000154	0.000162

The Vps and the Sps, were very close to their respective actual V and S values. **Appart for the last row**. In the last row the Vps and the Sps was larger than its measured value, additionally these values had the greatest disparity from its measured value.
This might be due to the beam reaching past the elastic limit at this point.

To improve accuracy, repeating the experiment with more loads (smaller loads to ensure not going over the elastic limit) and repeating the same loads to makes averages and eliminate anomalies

Conclusions

What I learnt:

I learnt how to process data to get the same final solution in two different ways, using equations and principles. Doing the experiment myself gave me a better understanding of material behaviour. I also learnt the value of keeping neat results table of recordings.

How can accuracy and usefulness be improved:

Using more sensitive instruments would help. Also having a system to attach the mass hangers on the beam in way that prevents them from ever so slightly moving when adding and removing weights as this can affect the recordings

In terms of usefulness, perhaps trying a wider range of materials or beam configurations. Also having a beam with a specific cross section shape, like a T, would change its vertical strength and make the experiment more useful for that specific shape.

What was good and not so good:

The setup as a whole was good, all the equipment was precise, accurate and modern. Having a digital displacement transducer saved a lot of time, equally did the strain gauge meter.

The system to hang the weights on the beam was not so good as it lacked preciseness (maybe having annotations on the beam can improve this)

How to improve practical arrangements:

It was difficult to accurately measure the distance from the fixed end to the hangers with a rigid ruler due to the support obstructing the view. A tape measurer would have been better in this case.