

Tensile test

Engineering Science (ACHA4002 & ACMA4028)

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Abbreviations

UWTSD	University of Wales Trinity Saint David
PVC	Polyvinyl Chloride
Pa	Pascals

2. Introduction

This report aims to display and analyse the results of a tensile test lab completed at UWTSD. It will also go over the method used to carry out the experiment, the results collected, an analysis of said results along with an evaluation on what methods were used to increase the accuracy of results on top of what potential methods could be used in future experiments to improve results.

3. Experimental procedure

3.1. Pre-test preparations

Rigorously read the lab guidance notes. Then select the specimen you wish to test and use a vernier to measure both the thickness and width of the specimen. Attach the specimen to the tensile tester and set the dial to zero

3.2. Testing phase

Turn the load nut in a clockwise direction at a constant steady speed, in 0.2mm increments until you reach 5mm then switch the increments to 1mm until you reach 10mm extension, finally switch to 10mm increments until the specimen breaks.

Record the dial indicator after every step

3.3. Post test phase

After the specimen breaks remove it from the tensile machine. To check how much the specimen has extended by push the broken ends together and measure its new length. Convert the dial readings into force values by multiplying them by 100. Subtract the dial indicator results from the load nut movement to find the extension at each stage of the experiment. Divide the extension at each stage by the original length to work out strain. Divide the force at each stage by the original cross-sectional area of the specimen to work out the stress

3.3. Post test analysis

Plot the stress/strain graphs of each specimen onto individual scatter graphs

Examine each graph to find the yield point of each and then plot a new graph of the elastic region of each specimen.

Find the gradient of each specimen's elastic region to find the young's modulus of the materials

4. Results

4.1. Steel

Load nut movement (mm)	Dial indicator (mm)
0	0
0.2	0.165
0.4	0.35
0.6	0.53
0.8	0.715
1	0.9
1.2	1.08
1.4	1.275
1.6	1.44
1.8	1.63
2	1.815
2.2	1.99
2.4	2.19
2.6	2.35
2.8	2.53
3	2.7
3.2	2.87
3.4	3.01
3.6	3.14
3.8	3.27
4	3.41
4.2	3.54
4.4	3.65
4.6	3.75
4.8	3.88
5	3.98
6	4.46
7	4.85
8	5.1
9	5.28
10	5.35

Original cross-sectional area: $0.9\text{mm} \times 1.98\text{mm} = 1.782 \times 10^{-6} \text{ m}^2$

Original length = 30.9mm

End length = 38.2mm

4.2. Duralumen

Load nut movement (mm)	Dial indicator (mm)
0	0
0.2	0.16
0.4	0.28
0.6	0.35
0.8	0.495
1	0.66
1.2	0.83
1.4	1.05
1.6	1.25
1.8	1.43
2	1.6
2.2	1.77
2.4	1.95
2.6	2.12
2.8	2.31
3	2.48
3.2	2.65
3.4	2.81
3.6	2.99
3.8	3.18
4	3.36
4.2	3.53
4.4	3.7
4.6	3.87
4.8	4.05
5	4.22
6	4.78
7	5
8	5.13

Original cross-sectional area: $1\text{ mm} \times 1.9\text{ mm} = 1.9 \times 10^{-6} \text{ m}^2$

Original length = 31mm

End length = 33.4mm

4.3. Aluminum

Load nut movement (mm)	Dial indicator (mm)
0	0
0.2	0.14
0.4	0.32
0.6	0.5
0.8	0.67
1	0.85
1.2	0.97
1.4	1.13
1.6	1.32
1.8	1.49
2	1.63
2.2	1.76
2.4	1.88
2.6	2.01
2.8	2.12
3	2.26
3.2	2.32
3.4	2.41
3.6	2.5
3.8	2.55
4	2.61
4.2	2.66
4.4	2.68
4.6	2.73
4.8	2.75

Original cross-sectional area: $1\text{ mm} \times 1.94\text{ mm} = 1.94 \times 10^{-6} \text{ m}^2$

Original length = 30.98mm

End length = 33.14mm

4.4. PVC

Load nut movement (mm)	Dial indicator (mm)
0	0
0.2	0.07
0.4	0.14
0.6	0.21
0.8	0.28
1	0.34
1.2	0.35
1.4	0.22
1.6	0.17
1.8	0.16
2	0.15
2.2	0.16
2.4	0.15
2.6	0.16
2.8	0.17
3	0.14
3.2	0.16
3.4	0.18
3.6	0.18
3.8	0.17
4	0.16
4.2	0.16
4.4	0.15
4.6	0.15
4.8	0.16
5	0.15
6	0.15
7	0.16
8	0.17
9	0.15
10	0.15

Original cross-sectional area: $1\text{mm} \times 1.9\text{mm} = 1.9 \times 10^{-6} \text{ m}^2$

Original length = 31.1mm

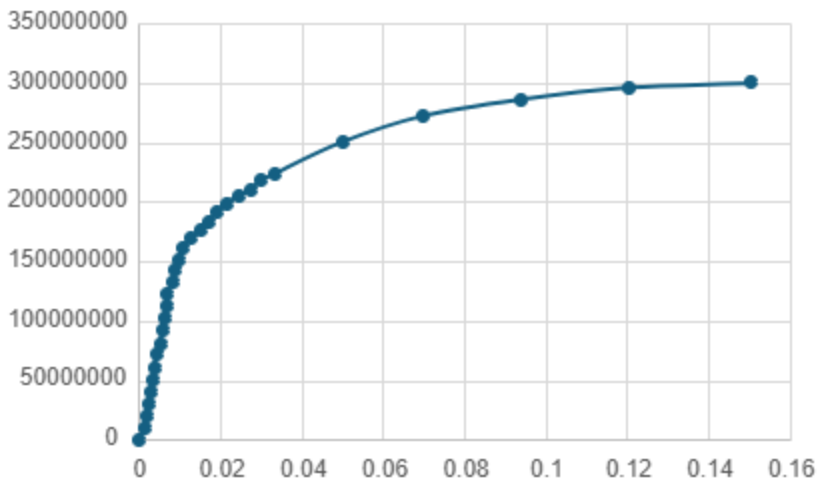
End length = 41.68mm

5. Analysis

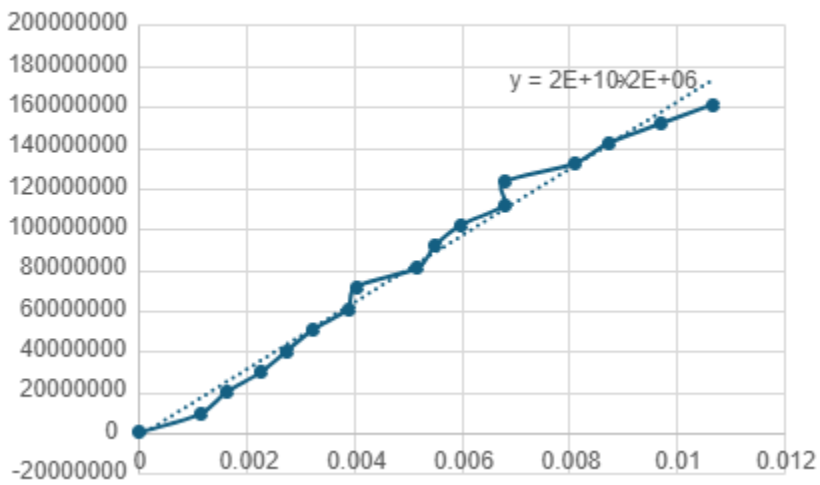
5.1. Steel

Load nut movement (mm)	Dial indicator (mm)	Force (N)	Extension (mm)	Stress (N/m ²)	Nominal strain	Steel
0	0	0	0	0	0	
0.2	0.165	16.5	0.035	9259259.259	0.001132686	
0.4	0.35	35	0.05	19640852.97	0.001618123	
0.6	0.53	53	0.07	29741863.08	0.002265372	
0.8	0.715	71.5	0.085	40123456.79	0.002750809	
1	0.9	90	0.1	50505050.51	0.003236246	
1.2	1.08	108	0.12	60606060.61	0.003883495	
1.4	1.275	127.5	0.125	71548821.55	0.004045307	
1.6	1.44	144	0.16	80808080.81	0.005177994	
1.8	1.63	163	0.17	91470258.14	0.005501618	
2	1.815	181.5	0.185	101851851.9	0.005987055	
2.2	1.99	199	0.21	111672278.3	0.006796117	
2.4	2.19	219	0.21	122895622.9	0.006796117	
2.6	2.35	235	0.25	131874298.5	0.008090615	
2.8	2.53	253	0.27	141975308.6	0.008737864	
3	2.7	270	0.3	151515151.5	0.009708738	
3.2	2.87	287	0.33	161054994.4	0.010679612	Yield point
3.4	3.01	301	0.39	168911335.6	0.012621359	
3.6	3.14	314	0.46	176206509.5	0.014886731	
3.8	3.27	327	0.53	183501683.5	0.017152104	
4	3.41	341	0.59	191358024.7	0.019093851	
4.2	3.54	354	0.66	198653198.7	0.021359223	
4.4	3.65	365	0.75	204826038.2	0.024271845	
4.6	3.75	375	0.85	210437710.4	0.027508091	
4.8	3.88	388	0.92	217732884.4	0.029773463	
5	3.98	398	1.02	223344556.7	0.033009709	
6	4.46	446	1.54	250280583.6	0.049838188	
7	4.85	485	2.15	272166105.5	0.069579288	
8	5.1	510	2.9	286195286.2	0.093851133	
9	5.28	528	3.72	296296296.3	0.12038835	
10	5.35	535	4.65	300224466.9	0.150485437	

Stress/strain of steel

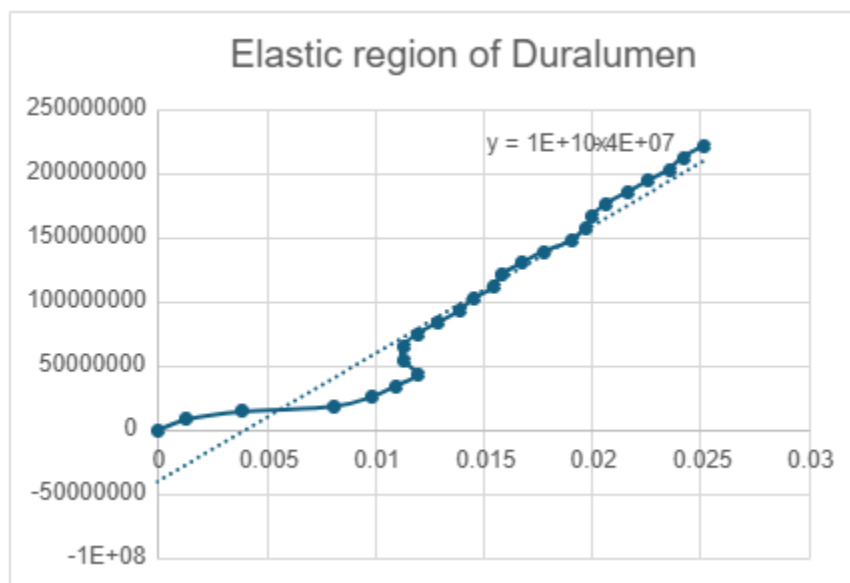
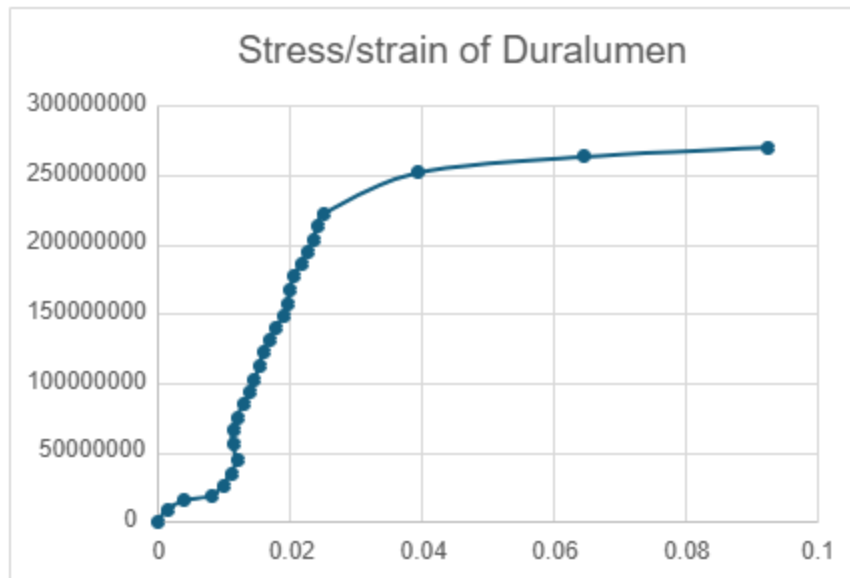


Elastic region of steel



5.2. Duralumen

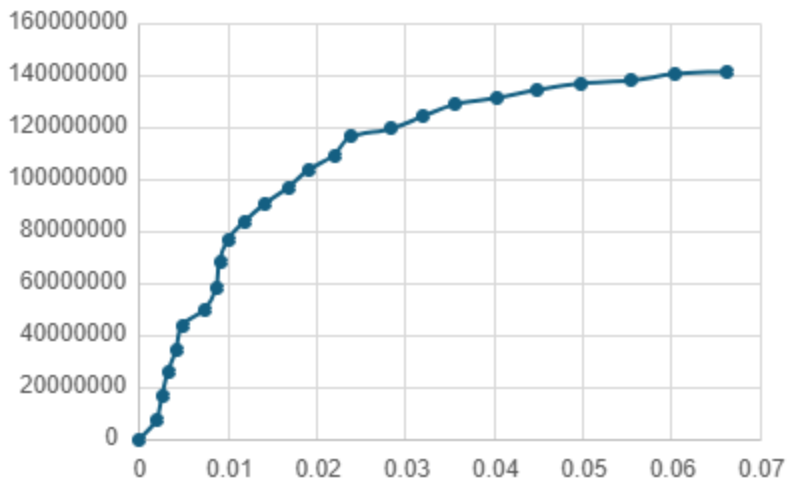
Load nut movement (mm)	Dial indicator (mm)	Force (N)	Extension (mm)	Stress (N/m ²)	Nominal strain	Duralumen
0	0	0	0	0	0	
0.2	0.16	16	0.04	8421052.632	0.001290323	
0.4	0.28	28	0.12	14736842.11	0.003870968	
0.6	0.35	35	0.25	18421052.63	0.008064516	
0.8	0.495	49.5	0.305	26052631.58	0.00983871	
1	0.66	66	0.34	34736842.11	0.010967742	
1.2	0.83	83	0.37	43684210.53	0.011935484	
1.4	1.05	105	0.35	55263157.89	0.011290323	
1.6	1.25	125	0.35	65789473.68	0.011290323	
1.8	1.43	143	0.37	75263157.89	0.011935484	
2	1.6	160	0.4	84210526.32	0.012903226	
2.2	1.77	177	0.43	93157894.74	0.013870968	
2.4	1.95	195	0.45	102631578.9	0.014516129	
2.6	2.12	212	0.48	111578947.4	0.015483871	
2.8	2.31	231	0.49	121578947.4	0.015806452	
3	2.48	248	0.52	130526315.8	0.016774194	
3.2	2.65	265	0.55	139473684.2	0.017741935	
3.4	2.81	281	0.59	147894736.8	0.019032258	
3.6	2.99	299	0.61	157368421.1	0.019677419	
3.8	3.18	318	0.62	167368421.1	0.02	
4	3.36	336	0.64	176842105.3	0.020645161	
4.2	3.53	353	0.67	185789473.7	0.021612903	
4.4	3.7	370	0.7	194736842.1	0.022580645	
4.6	3.87	387	0.73	203684210.5	0.023548387	
4.8	4.05	405	0.75	213157894.7	0.024193548	
5	4.22	422	0.78	222105263.2	0.02516129	Yield point
6	4.78	478	1.22	251578947.4	0.039354839	
7	5	500	2	263157894.7	0.064516129	
8	5.13	513	2.87	270000000	0.092580645	



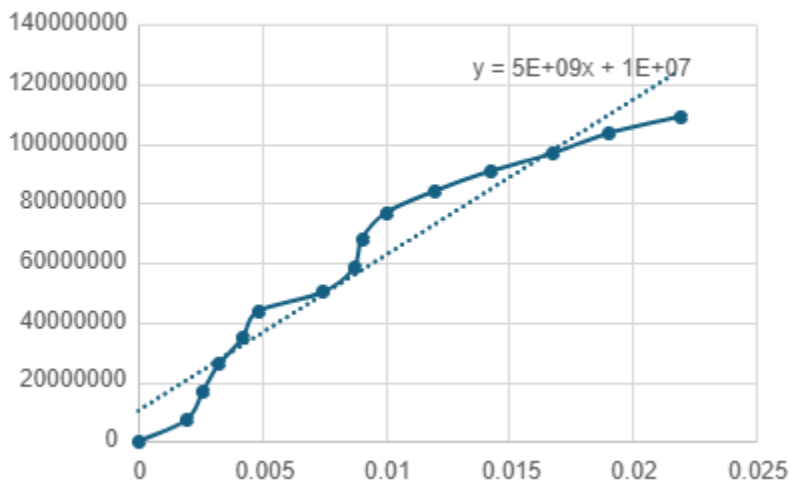
5.3. Aluminum

Load nut movement (mm)	Dial indicator (mm)	Force (N)	Extension (mm)	Stress (N/m ²)	Nominal strain	Aluminium
0	0	0	0	0	0	
0.2	0.14	14	0.06	7216494.845	0.001936733	
0.4	0.32	32	0.08	16494845.36	0.002582311	
0.6	0.5	50	0.1	25773195.88	0.003227889	
0.8	0.67	67	0.13	34536082.47	0.004196256	
1	0.85	85	0.15	43814432.99	0.004841833	
1.2	0.97	97	0.23	50000000	0.007424145	
1.4	1.13	113	0.27	58247422.68	0.0087153	
1.6	1.32	132	0.28	68041237.11	0.009038089	
1.8	1.49	149	0.31	76804123.71	0.010006456	
2	1.63	163	0.37	84020618.56	0.011943189	
2.2	1.76	176	0.44	90721649.48	0.014202711	
2.4	1.88	188	0.52	96907216.49	0.016785023	
2.6	2.01	201	0.59	103608247.4	0.019044545	
2.8	2.12	212	0.68	109278350.5	0.021949645	yield point
3	2.26	226	0.74	116494845.4	0.023886378	
3.2	2.32	232	0.88	119587628.9	0.028405423	
3.4	2.41	241	0.99	124226804.1	0.031956101	
3.6	2.5	250	1.1	128865979.4	0.035506779	
3.8	2.55	255	1.25	131443299	0.040348612	
4	2.61	261	1.39	134536082.5	0.044867657	
4.2	2.66	266	1.54	137113402.1	0.04970949	
4.4	2.68	268	1.72	138144329.9	0.05551969	
4.6	2.73	273	1.87	140721649.5	0.060361524	
4.8	2.75	275	2.05	141752577.3	0.066171724	

Stress/strain of Aluminium



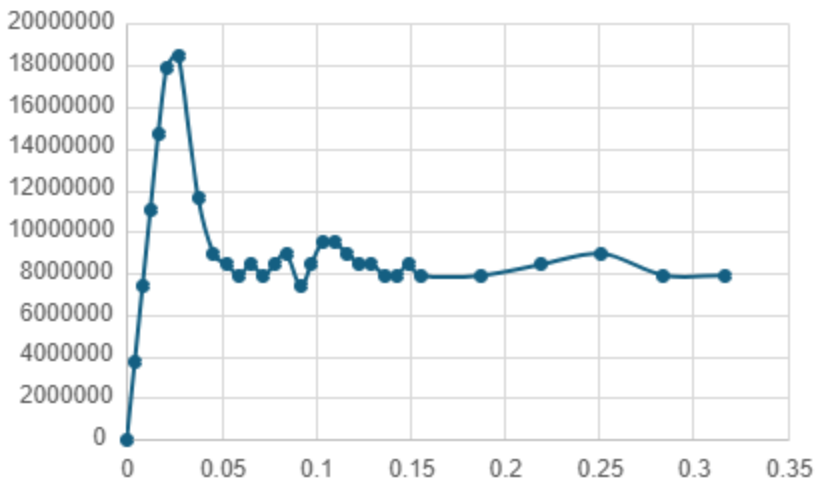
Elastic range of Aluminium



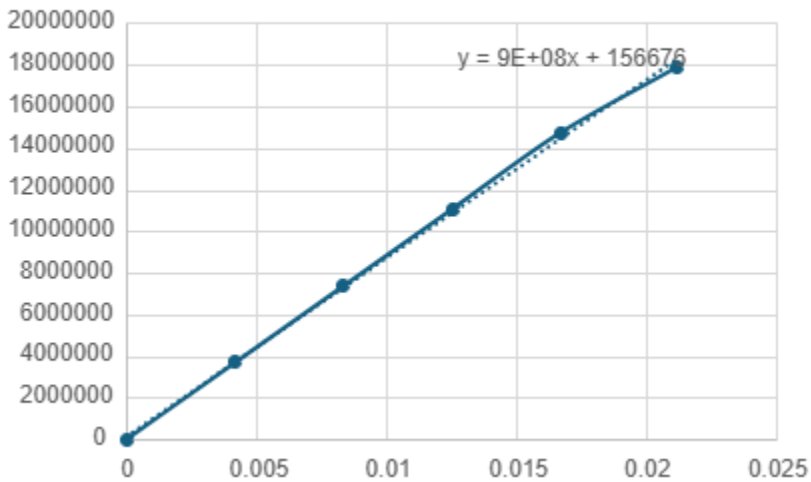
5.4. PVC

Load nut movement (mm)	Dial indicator (mm)	Force (N)	Extension (mm)	Stress (N/m ²)	Nominal strain	PVC
0	0	0	0	0	0	
0.2	0.07	7	0.13	3684210.526	0.004180064	
0.4	0.14	14	0.26	7368421.053	0.008360129	
0.6	0.21	21	0.39	11052631.58	0.012540193	
0.8	0.28	28	0.52	14736842.11	0.016720257	
1	0.34	34	0.66	17894736.84	0.021221865	Yield
1.2	0.35	35	0.85	18421052.63	0.02733119	
1.4	0.22	22	1.18	11578947.37	0.037942122	
1.6	0.17	17	1.43	8947368.421	0.045980707	
1.8	0.16	16	1.64	8421052.632	0.052733119	
2	0.15	15	1.85	7894736.842	0.059485531	
2.2	0.16	16	2.04	8421052.632	0.065594855	
2.4	0.15	15	2.25	7894736.842	0.072347267	
2.6	0.16	16	2.44	8421052.632	0.078456592	
2.8	0.17	17	2.63	8947368.421	0.084565916	
3	0.14	14	2.86	7368421.053	0.091961415	
3.2	0.16	16	3.04	8421052.632	0.097749196	
3.4	0.18	18	3.22	9473684.211	0.103536977	
3.6	0.18	18	3.42	9473684.211	0.109967846	
3.8	0.17	17	3.63	8947368.421	0.116720257	
4	0.16	16	3.84	8421052.632	0.123472669	
4.2	0.16	16	4.04	8421052.632	0.129903537	
4.4	0.15	15	4.25	7894736.842	0.136655949	
4.6	0.15	15	4.45	7894736.842	0.143086817	
4.8	0.16	16	4.64	8421052.632	0.149196141	
5	0.15	15	4.85	7894736.842	0.155948553	
6	0.15	15	5.85	7894736.842	0.188102894	
7	0.16	16	6.84	8421052.632	0.219935691	
8	0.17	17	7.83	8947368.421	0.251768489	
9	0.15	15	8.85	7894736.842	0.284565916	
10	0.15	15	9.85	7894736.842	0.316720257	

Stress/Strain of PVC



Elastic region of PVC



6. Conclusion

6.1. Steel

6.1.1. Youngs modulus

For the tensile strength test of steel, the determined youngs modulus was 2×10^{10} Pa. Comparing this to the most accepted value of 2×10^{11} Pa (SUGNA, 2023) you can tell there is a significant difference in the theoretical answer and the measured one.

6.1.2. Yield stress

The measured yield stress for steel was 170 MPa which compared to the usual range of steel yield stress of between 250 MPa and exceeding 600 MPa (Econ Steel, 2024) is less than what should be expected for this sample.

6.1.3. Tensile strength

The measured tensile strength of the steel sample was 3×10^8 Pa, comparing this number to the typical tensile strength of steel which is between 400 MPa and 700 MPa (Econ Steel, 2024) you can see this is below the expected tensile strength of a typical steel sample.

6.1.4. Elongation

The measured elongation of steel in the test was 23.6%, compared to the usual measured extension of steel which is 10%-20% (Xometry, 2023). This is slightly atypical, however not far from the measured elongation.

6.2. Duralumin

6.2.1. Youngs modulus

For the tensile strength test of duralumin, the determined youngs modulus was 1×10^{10} Pa. Comparing this to the most accepted value of 76 GPa (Nuclear power, 2024) you can tell there is a large difference in the theoretical answer and the measured one.

6.2.2. Yield stress

The measured yield stress for duralumin was 2.2×10^8 Pa which if you compared to the usual duralumin yield stress of around 450 MPa (Chem Europe, 2024) is less than what typically would be expected for this sample.

6.2.3. Tensile strength

The measured tensile strength of the duralumin sample was 2.7×10^8 Pa, comparing this number to the typical tensile strength of duralumin which is between 420 MPa and 500 MPa (AZO materials, 2013) you can see this is around half the expected tensile strength of a typical duralumin sample.

6.2.4. Elongation

The measured elongation of duralumin in the test was 7.7%, compared to the usual measured extension of aluminum which is 22% (AZO materials, 2013). This is very different, and shows the sample tested had a low strain before breaking.

6.3. Aluminum

6.3.1. Youngs modulus

For the tensile strength test of aluminum, the determined youngs modulus was 5×10^9 Pa. Comparing this to a typical value of 73 GPa (Britannica, 2024) you can tell there is a large difference in the theoretical answer and the measured one.

6.3.2. Yield stress

The measured yield stress for aluminum was 1.1×10^8 Pa which if you compared to the usual aluminum yield stress of around 30 MPa (sunrise metal, 2024) you will see it is only around a third of what's expected.

6.3.3. Tensile strength

The measured tensile strength of the aluminum sample was 1.4×10^8 Pa, comparing this number to the typical tensile strength of aluminum which is around 90 MPa (Alco, 2024) you can see this is massively underneath the expected tensile strength.

6.3.4. Elongation

The measured elongation of aluminum in the test was 7%, compared to the usual measured extension of aluminum which is 8% (Italpres, 2024). This is very similar to the measured result.

6.3. PVC

6.4.1. Youngs modulus

For the tensile strength test of PVC, the determined youngs modulus was 9×10^8 Pa. Comparing this to a typical value of 3.7 GPa (Oxford reference, 2024) there is quite a difference in the theoretical answer and the measured one however this was likely due to environmental factors.

6.4.2. Yield stress

The measured yield stress for PVC was 1.8×10^7 Pa which if you compared to the usual PVC yield stress of around 3.45 MPa to 73.1 MPa (matweb, 2024) you will see it is only slightly outside the lower band of expected results.

6.4.3. Tensile strength

The measured tensile strength of the PVC sample was 1.4×10^8 Pa, comparing this number to the typical tensile strength of PVC which is around 16 MPa (Oxford reference, 2024) you can see this is less than a tenth of the expected tensile strength.

6.4.4. Elongation

The measured elongation of aluminum in the test was 34%, compared to the usual measured extension of aluminum which is between 30% and 40% (Material science and engineering, 2007). This is exactly in the range of expected results.

7. Evaluation

To improve the accuracy of the test we took several precautions, we had the same person turn the dial knob each time to the force applied was the same, the same person reading the DTI to they were measuring at the same time and the same environment for all materials.

8. Further work

8.1. How the test could be improved

This experiment could be improved in various ways given no constraints. Number one is temperature control of samples, increasing/decreasing the temperature of materials greatly changes their properties thus will change the results of a tensile test. Digitizing the dial indicator is also an option which will eliminate human errors like reaction time and parallax error to improve accuracy. Finally having a machine control the load nut movement would ensure a smooth and uniform force is applied on the sample at each stage.

9. References

Sugna, 2023. SUGNA premium steel

Available at: [https://sugnatmt.com/youngs-modulus-of-steel/#:~:text=Known%20for%20its%20impressive%20strength,per%20square%20inch%20\(psi\).](https://sugnatmt.com/youngs-modulus-of-steel/#:~:text=Known%20for%20its%20impressive%20strength,per%20square%20inch%20(psi).)

Econ Steel, 2024. Econ steel Tensile strength vs yield strength

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