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Tensile Test Report

Engineering Science

(ACHA4002 & ACMA4028)

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1. Introduction

This report will cover the Tensile experiments that were conducted with four various specimens, with the data gathered four graphs were produced to determine the Tensile strength, ‘the maximum load that a specimen can support without deforming (Encyclopaedia Britannica, 2024)’, Yield stress, ‘the maximum stress that a material can undergo without causing plastic deformation (Gopal, 2024)’ the percentage of elongation and the young’s modulus value for each of the materials. This report also consists of a step-by-step process of the experiment that was conducted using the testing kit found with the lab, using the data gathered in this process enable the stress and strain to be calculated.

2. Experimental Procedure



Figure 2-1 The four Materials used within the Experiment (D.Briggs, 2024)

Prior to the initial start of the experiment, all the materials were gathered to be measured for their length, depth and width so that the cross-sectional area could be calculated. The materials used in this experiment were Mild Steel, Duralumin, Aluminium and PVC, the Aluminium being identified by the small notch indented on the side of the piece.

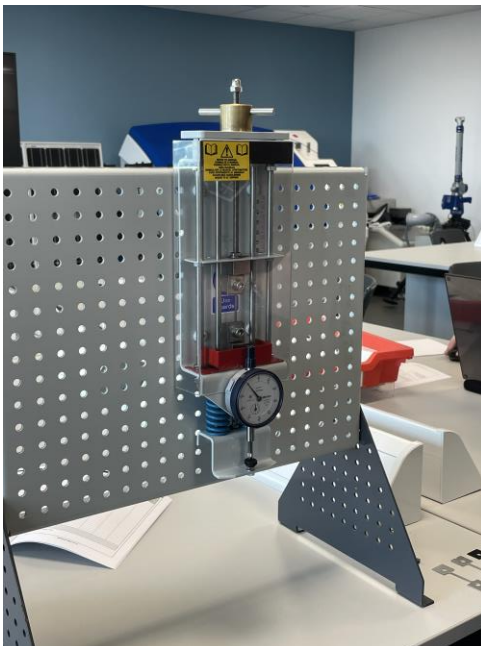
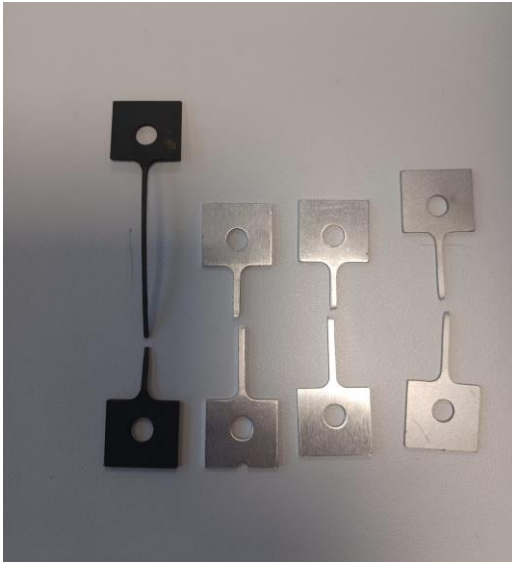


Figure 2-2 The Tensile Testing Kit (F.Flye, 2024)

The initial step of this procedure was to set up the tensile testing kit using two bolts that were fastened to the work panel to hold the device upright. Once the device was in place the first material was locked in with two screws using 'the large flat area at each of the opposing ends (TecQuipment, 2024)' then ensuring that the guard was in place the experiment could be carried out.



Once the experiment was repeated on the other three specimens, were gathered to be re-measured to determine their final lengths as shown here. Using the data collected prior to the experiment and after the experiment had concluded the percentage of elongation was able to be calculated using the final length and the initial length of the material.

Figure 2-3 The Final lengths of the Materials
(D.Briggs, 2024)

3. Results

This Section includes the Raw data recorded at the time of the experiment for each of the four materials, the tables below show the Load nut movement up until the point of fracture with the corresponding reading from the dial indicator.

Table 1 Raw Data collected for Mild Steel (F.Flye, 2024)

Load Nut Movement (mm)	Dial Indicator (mm)
0	0
0.4	0.25
0.6	0.45
0.8	0.63
1	0.81
1.2	1.00
1.4	1.17
1.6	1.38
1.8	1.56
2	1.75
2.2	1.93
2.4	2.12
2.6	2.31
2.8	2.49
3	2.66
3.2	2.84
3.4	3.00
3.6	3.14
3.8	3.25
4	3.37
4.2	3.50
4.4	3.62
4.6	3.74
4.8	3.85
5	3.96
6	4.43
7	4.77
8	5.00
9	5.24
10	5.30

Table 2 Raw Data for Aluminium (F.Flye, 2024)

Load Nut movement (mm)	Dial Indicator (mm)
0	0
0.2	0.17
0.4	0.34
0.6	0.52
0.8	0.7
1	0.87
1.2	1.00
1.4	1.24
1.6	1.41
1.8	1.58
2	1.75
2.2	1.89
2.4	2.00
2.6	2.09
2.8	2.2
3	2.26
3.2	2.38
3.4	2.43
3.6	2.51
3.8	2.58
4	2.61
4.2	2.67
4.4	2.70
4.6	2.7
4.8	2.7

Table 3 Raw Data for Duralumin (F.Flye, 2024)

Load Nut movement (mm)	Dial Indicator
0	0
0.2	0.17
0.4	0.35
0.6	0.54
0.8	0.73
1	0.90
1.2	1.10
1.4	1.28
1.6	1.48
1.8	1.65
2	1.83
2.2	2.02
2.4	2.20
2.6	2.39
2.8	2.57
3	2.74
3.2	2.92
3.4	3.10
3.6	3.28
3.8	3.46
4	3.64
4.2	3.82
4.4	4.00
4.6	4.16
4.8	4.32
5	4.46
6	4.75
7	4.92

Table 4 Raw Table for PVC (F.Flye, 2024)

Load Nut movement (mm)	Dial Indicator (mm)
0	0
0.2	0.06
0.4	0.13
0.6	0.19
0.8	0.19
1	0.23
1.2	0.25
1.4	0.27
1.6	0.18
1.8	0.15
2	0.13
2.2	0.13
2.4	0.15
2.6	0.14
2.8	0.14
3	0.14
3.2	0.14
3.4	0.15
3.6	0.14
3.8	0.14
4	0.14
4.2	0.15
4.4	0.14
4.6	0.14
4.8	0.14
5	0.14
6	0.13
7	0.12
8	0.11
9	0.12
10	0.14
20	0.11
30	0.11
40	0.08

4. Analysis

In the Table above is the data collected after the experiment was concluded, using the Raw Data recorded the missing values were able to be calculated as shown in the table below, using equations sourced from 'Tensile Tester Kit ES6 booklet.

Table 5 Calculated Values for Mild Steel (F.Flye,2024)

Force (N)	Extension (mm)	Stress σ (N/m ²)	Nominal Strain ϵ	Stress σ (kN/m ²)
0	0	0	0	0
25	0.15	384024.58	0.207	384.02
45	0.15	691244.24	0.207	691.24
63	0.17	967741.94	0.182	967.74
81	0.19	1244239.63	0.163	1244.24
100	0.2	1536098.31	0.155	1536.10
117	0.23	1797235.02	0.135	1797.24
138	0.22	2119815.67	0.141	2119.82
156	0.24	2396313.36	0.129	2396.31
175	0.25	2688172.04	0.124	2688.17
193	0.27	2964669.74	0.115	2964.67
212	0.28	3256528.42	0.111	3256.53
231	0.29	3548387.10	0.107	3548.39
249	0.31	3824884.79	0.100	3824.88
266	0.34	4086021.51	0.091	4086.02
284	0.36	4362519.20	0.086	4362.52
300	0.4	4608294.93	0.077	4608.29
314	0.46	4823348.69	0.067	4823.35
325	0.55	4992319.51	0.056	4992.32
337	0.63	5176651.31	0.049	5176.65
350	0.7	5376344.09	0.044	5376.34
362	0.78	5560675.88	0.040	5560.68
374	0.86	5745007.68	0.036	5745.01
385	0.95	5913978.49	0.033	5913.98
396	1.04	6082949.31	0.030	6082.95
443	1.57	6804915.51	0.020	6804.92
477	2.23	7327188.94	0.014	7327.19
500	3	7680491.55	0.010	7680.49
524	3.76	8049155.15	0.008	8049.16
530	4.7	8141321.04	0.007	8141.32

Table 6 Dimensions for Mild Steel (F.Flye, 2024)

Material:	Mild Steel	Length After:	0.039 (m)
Original Cross sectional area:	0.0000651 (m ²)	Width:	0.0021 (m)
Original Length:	0.031 (m)	Depth:	0.0009 (m)

Table 7 Calculations for Aluminium (F.Flye, 2024)

Force (N)	Extension (mm)	Stress σ (N/m ²)	Nominal Strain ϵ	Stress σ (kN/m ²)
0	0	0	0	0
17	0.03	279789.34	1.033	279.79
34	0.06	559578.67	0.517	559.58
52	0.08	855826.20	0.388	855.83
70	0.1	1152073.73	0.310	1152.07
87	0.13	1431863.07	0.238	1431.86
100	0.20	1645819.62	0.155	1645.82
124	0.16	2040816.33	0.194	2040.82
141	0.19	2320605.66	0.163	2320.61
158	0.22	2600395.00	0.141	2600.39
175	0.25	2880184.33	0.124	2880.18
189	0.31	3110599.08	0.100	3110.60
200	0.40	3291639.24	0.078	3291.64
209	0.51	3439763.00	0.061	3439.76
220	0.6	3620803.16	0.052	3620.80
226	0.74	3719552.34	0.042	3719.55
238	0.82	3917050.69	0.038	3917.05
243	0.97	3999341.67	0.032	3999.34
251	1.09	4131007.24	0.028	4131.01
258	1.22	4246214.61	0.025	4246.21
261	1.39	4295589.20	0.022	4295.59
267	1.53	4394338.38	0.020	4394.34
270	1.70	4443712.97	0.018	4443.71
270	1.9	4443712.97	0.016	4443.71
270	2.1	4443712.97	0.015	4443.71

Table 8 Dimensions of Aluminium (F.Flye, 2024)

Material:	Aluminium	Lenth after:	0.03394 (m)
Original Cross-Sectional Area:	0.00006076 (m ²)	Width:	0.00196 (m)
Original Length:	0.031 (m)	Depth:	0.001 (m)

Table 9 Calculations for Duralumin

Force (N)	Extension (mm)	Stress σ (N/m ²)	Nominal Strain ϵ	Stress σ (kN/m ²)
0	0	0	0	0
17	0.03	277859.50	1.03	277.8595012
35	0.05	572063.68	0.62	572.0636789
54	0.06	882612.53	0.52	882.6125331
73	0.07	1193161.39	0.44	1193.161387
90	0.10	1471020.89	0.31	1471.020888
110	0.10	1797914.42	0.31	1797.914419
128	0.12	2092118.60	0.26	2092.118597
148	0.12	2419012.13	0.26	2419.012128
165	0.15	2696871.63	0.21	2696.871629
183	0.17	2991075.81	0.18	2991.075807
202	0.18	3301624.66	0.17	3301.624661
220	0.20	3595828.84	0.15	3595.828839
239	0.21	3906377.69	0.15	3906.377693
257	0.23	4200581.87	0.13	4200.58187
274	0.26	4478441.37	0.12	4478.441372
292	0.28	4772645.55	0.11	4772.645549
310	0.30	5066849.73	0.10	5066.849727
328	0.32	5361053.90	0.10	5361.053905
346	0.34	5655258.08	0.09	5655.258082
364	0.36	5949462.26	0.09	5949.46226
382	0.38	6243666.44	0.08	6243.666438
400	0.40	6537870.62	0.08	6537.870616
416	0.44	6799385.44	0.07	6799.38544
432	0.48	7060900.26	0.06	7060.900265
446	0.54	7289725.74	0.06	7289.725736
475	1.25	7763721.36	0.02	7763.721356
492	2.08	8041580.86	0.01	8041.580857

Table 10 Dimensions for Duralumin (F.Flye, 2024)

Material:	Duralumin	Length After:	0.033 (m)
Original Cross-Sectional Area:	0.000061182 (m ²)	Width:	0.00198 (m)
Original length:	0.0309 (m)	Depth:	0.0001 (m)

Table 11 Calculations for PVC (F.Flye, 2024)

Force (N)	Extension (mm)	Stress σ (N/m ²)	Nominal Strain ϵ	Stress σ (kN/m ²)
0	0	0	0	0
6	0.14	98874.15	0.223	98.87
13	0.27	214227.33	0.116	214.23
19	0.41	313101.48	0.076	313.10
19	0.61	313101.48	0.051	313.10
23	0.77	379017.59	0.041	379.02
25	0.95	411975.64	0.033	411.98
27	1.13	444933.69	0.028	444.93
18	1.42	296622.46	0.022	296.62
15	1.65	247185.38	0.019	247.19
13	1.87	214227.33	0.017	214.23
13	2.07	214227.33	0.015	214.23
15	2.25	247185.38	0.014	247.19
14	2.46	230706.36	0.013	230.71
14	2.66	230706.36	0.012	230.71
14	2.86	230706.36	0.011	230.71
14	3.06	230706.36	0.010	230.71
15	3.25	247185.38	0.010	247.19
14	3.46	230706.36	0.009	230.71
14	3.66	230706.36	0.009	230.71
14	3.86	230706.36	0.008	230.71
15	4.05	247185.38	0.008	247.19
14	4.26	230706.36	0.007	230.71
14	4.46	230706.36	0.007	230.71
14	4.66	230706.36	0.007	230.71
14	4.86	230706.36	0.006	230.71
13	5.87	214227.33	0.005	214.23
12	6.88	197748.31	0.005	197.75
11	7.89	181269.28	0.004	181.27
12	8.88	197748.31	0.004	197.75
14	9.86	230706.36	0.003	230.71
11	19.89	181269.28	0.002	181.27
11	29.89	181269.28	0.001	181.27
8	39.92	131832.20	0.001	131.83

Table 12 Dimensions for PVC (F.Flye, 2024)

Material:	PVC	Length after:	0.06582 (m)
Original Cross-Sectional Area:	6.06832E-05 (m ²)	Width:	0.00194 (m)
Original length:	0.03128 (m)	Depth:	0.0001 (m)

To Calculate the Force applied by the device the equation $\text{Force} = \text{Dial Indicator} \times 100$

Using the Load Nut movement and the Dial indicator enabled the Extension to be calculated using the equation; $\text{Ex} = \text{Load Nut Movement} - \text{Dial Indicator}$

For example, using the values 0.2mm and 0.06mm the Extension placed on the material would be, $\text{Ex} = 0.2 - 0.06$

$$\text{Ex} = 0.14\text{mm}$$

To obtain the values of Stress the equation $\sigma = \text{Force}/A$

'A' being the original cross-sectional area of the material which can be calculated by using the equation; $A = \text{length} \times \text{width}$

To Calculate the Strain put on the material the equation; $\epsilon = \text{length change} / \text{original length}$ was used.

So, to Calculate a value of Strain for Mild Steel; $\epsilon = 0.031 / 0.15$

$$\epsilon = 0.207$$

After Calculating all the required Data for the materials this enabled four graphs to be plotted, showing the relationship between Stress and Extension that enable further calculations to determine the value of tensile strength, the yield strength and the value for young's modulus.

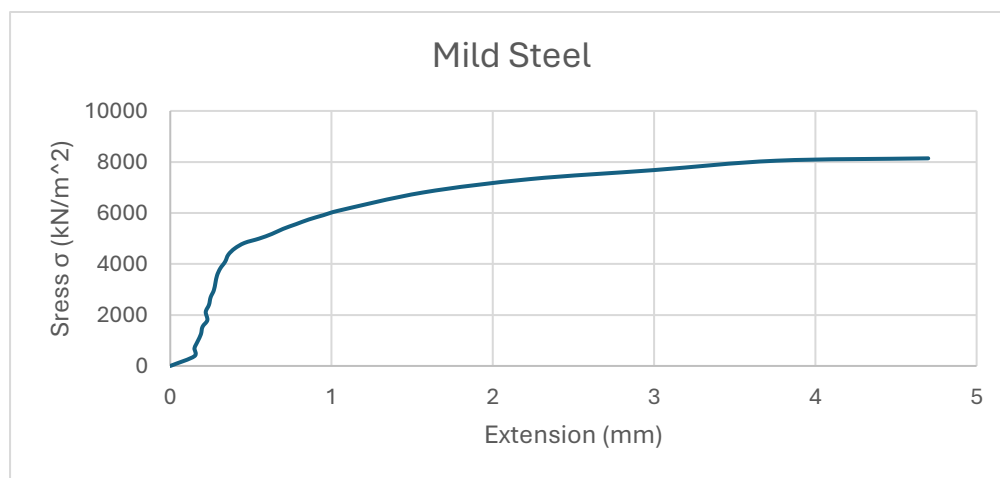


Figure 4-1 Stress against Extension for Mild Steel (F.Flye, 2024)

Using the graph and the data I was able to calculate and decipher these values;

Table 13 Calculations From Mild Steel graph (F.Flye, 2024)

Tensile Strength:	8049155	(N/m ²)
Yield Stress:	5176651	(N/m ²)
% Elongation:	25.81	%
Young's Modulus:	50661513	Pa

To determine the value of Tensile Strength I used the equation; $\text{TS} = \text{Maximum Force}/A$

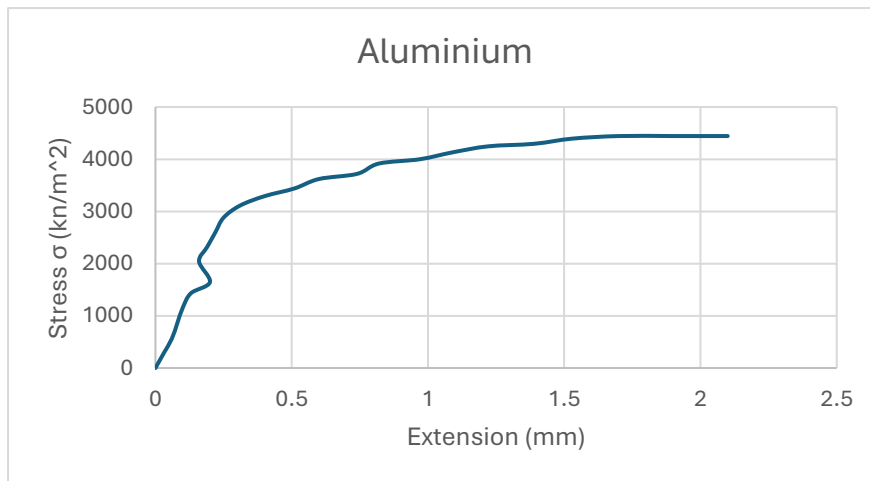


Figure 4-2 Stress against Extension for Aluminium (F.Flye, 2024)

This graph presents an anomaly within the region between 1000 and 2000 (kN/m²) where human error has occurred when reading the dial indicator as a result of this the graph bends inwards causing a slight indentation into the data which could cause problems for further calculations.

Table 14 Calculations From Aluminium graph (F.Flye, 2024)

Tensile Strength:	4443713	(N/m ²)
Yield Stress:	3110599	(N/m ²)
% Elongation:	9.48	%
Young's Modulus:	23227293	Pa

To calculate the values of Elongation percentage the equation used was;

$$\% \text{ Elongation} = (\text{Length After-Original Length}) / (\text{Original Length}) \times 100$$

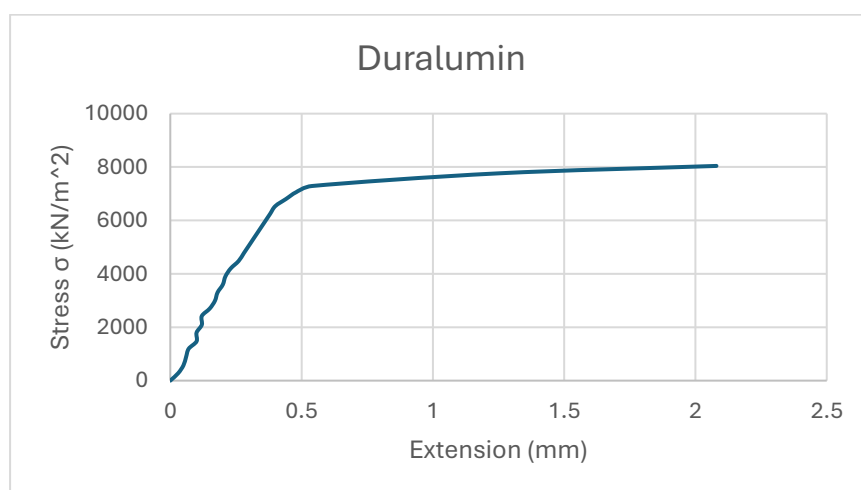


Figure 4-3 Stress against Extension for Duralumin (F.Flye, 2024)

Table 15 Calculations From Duralumin (F.Flye, 2024)

Tensile Strength :	8041581	(N/m ²)
Yield Strength:	7289726	(N/m ²)
% Elongation:	6.80	%
Young's Modulus:	31266467	Pa

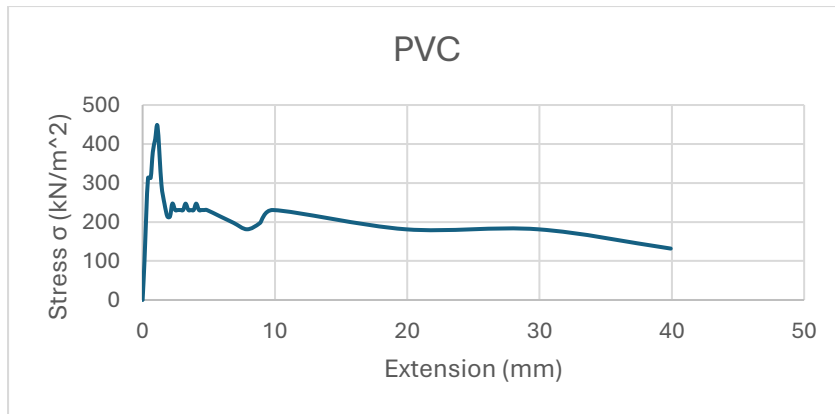


Figure 4-4 Stress against Extension for PVC (F.Flye, 2024)

Table 16 Calculations From PVC graph (F.Flye, 2024)

Tensile Strength:	444933.7	(N/m ²)
Yield Strength:	313101.5	(N/m ²)
% Elongation :	110.422	%
Young's Modulus:	4103952	Pa

From the graphs above a trend between the value of stress and extension can be determined that as the value for extension increases the value of stress increase until the point of fracture. However, the value for PVC doesn't follow this trend as it undergoes plastic deformation this is known as the plastic region on the graph where the material will never go back to its original state as the PVC is subjected to a load of stress that reaches past its yield strength.

5. Conclusion

To conclude through the data recorded it was found that Mild Steel had the highest tensile strength of that at 8049155 N/m^2 as well as the highest Young's modulus value at 50.66 MPa as steel is an alloy formed from carbon and iron that 'gives it a robust structural lattice that increases its tensile strength (ServiceSteel, 2024)'. Then when calculating the elongation percentage of the materials it was found that PVC had the highest elongation at 110% as it stretched due to the fact that plastics are more capable of undergoing stress without permanent deformation as it stretched over 30mm before the final fracture. Finally, Duralumin has the highest yield strength of that at 7289726 N/m^2 as Duralumin 'as alloys typically complex structures that enable them to resist deformation (TutorChase, 2024)' this solidifies the accuracy of the data collected.

To compare the results recorded to the nominal values of both tensile and yield strength, the tensile value for Mild Steel is ' 420 MPa and the yield value is 350 MPa (MatWeb, 2024)' whereas the values recorded with the lab were 8.09 MPa and 5.18 MPa this is due to using a smaller material and device. For Aluminium the nominal value for tensile strength is ' 90 MPa and a yield strength of 34 MPa (AmesWeb, 2024)' whereas the value calculated for tensile strength was 4.44 MPa and the value for yield strength was 3.11 MPa , this shortage was due to the lack of reciprocity within the experiments. In the case Duralumin the nominal value for tensile strength is ' $420 \text{ MPa} - 500 \text{ MPa}$ (Azo, 2013) and the yield strength being ' 450 MPa (ChemistryLearner, 2024) whereas the values collected were 8.04 MPa and the yield strength at 7.28 MPa . Finally, for PVC the standard value for tensile strength is ' $14.3 \text{ MPa} - 55.2 \text{ MPa}$ and for yield strength $3.45 \text{ MPa} - 73.1 \text{ MPa}$ (MatWeb, 2024)' as the calculated value of tensile strength from the lab was 0.44 MPa and 0.31 MPa these differences could be due to the temperature at which the experiment was conducted at.

6. Evaluation

There are various processes to minimize the occurrence of error when conducting an experiment, the steps that were taken when proceeding with this experiment were being consistent when turning the load nut to ensure that the values given by the dial indicator are accurate. That the person reading the values from the dial indicator were calm and collected to ensure that they wouldn't interpret the value wrong or miss the value before the dial begins to drop. Additionally, when the load nut is being turned it was ensured that minimal time was taken in between intervals so that the material didn't have time to relax. Another factor that was considered was that the person writing the values down ensured that he was focused and ready to write the data down as soon as he was given the values.

When taking the measurements before the experiment it was ensured that all the dimensions were accurate as it was found that all the materials had various dimensions, which affected the cross-sectional area value for each of the materials. Furthermore, when measuring after the experiment had been conducted it was ensured that a second person was holding end of the materials to ensure there was no movement in the material so the measurements would be precise to reduce error for the further calculations.

7. Further Work

To further improve this experiment would be a bigger environment so that a bigger piece of equipment could be used to ensure the safety of the personnel conducting the experiment, with this an automated system could be adapted to rotate the load nut accurately and efficiently to each mark to ensure the utmost accurate reading from the dial indicator. The reading from the dial indicator could then be transferred to a digital screen or clock to show the exact measurement, using this would completely eliminate the possibility of human error as it is all digitized.

When conducting this experiment and using the machinery only a single person should operate to reduce the occurrence of human error, once completed other members should examine the collected data and cross reference to come to an accurate answer. Furthermore, two of each material should be used to compare the data received to identify any anomalies or to ensure the precision of the data. Another factor that could be altered is the temperature of the room or machine that the experiment is conducted in as temperature effects the expansion of the materials giving higher results.

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