



Experimental Testing of Tensile Strength

Engineering Science 1 & Laboratory Skills (ACMA4033)

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Introduction

This report aims to discuss the results of an experiment performed to test the tensile strength of Steel, Aluminium, Duralumin and PVC.

Stress, Strain and Young's Modulus

Stress is a measurement of an external force acting over the cross sectional area of a material. Due to this stress is expressed as a pressure in the unit Pascalls (Pa) or Nm^{-2} . Two types of stress exist. Normal stress and shear stress. Normal stress is where the force acts normally or perpendicular to the surface and shear stress is when it acts parallel. (Boston University).

Strain is a unitless measurement of the decimal percentage increase or decrease of the length of a material under load. Like stress, strain also has two forms. Normal strain and shear strain which are applied the same. (Boston University)

When plotted on a graph against each other stress and strain have a distinct linear region and a distinct non linear region. The linear region is also known as the elastic region as when stretched in this region the material is able to return back to its original length.

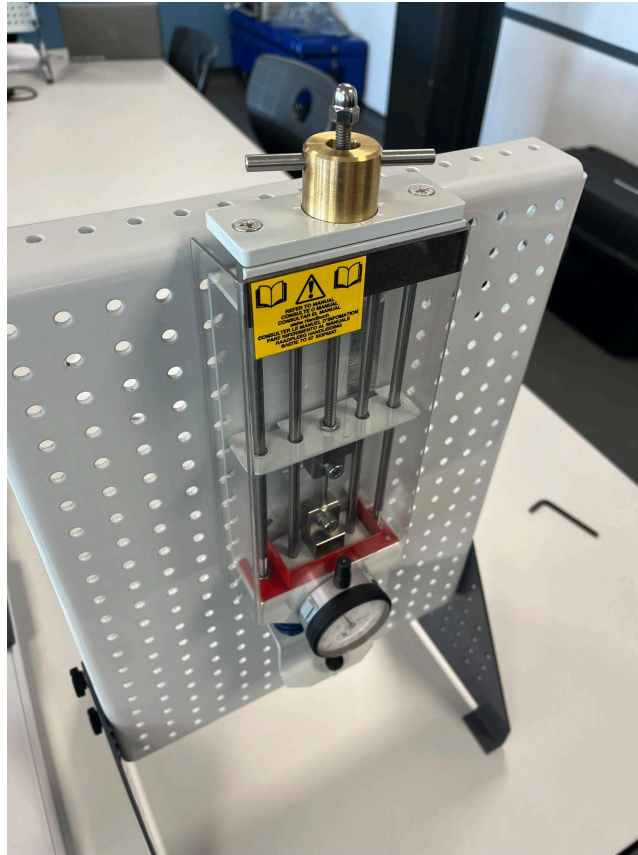
However, once the material stretches into the non linear region, also known as the plastic region, it is then unable to return to it's original length. The gradient of the line in the linear region is known as the Young's modulus of the material. Discovered in the 18th century by Thomas Young, the Young's modulus of a material describes the relationship of stress, and the components that make it up, to strain, and the components that make it up. Engineers use this to work out how far any given part will deform under load with respect to its material and shape (Encyclopedia Britannica).

Tensile Testing

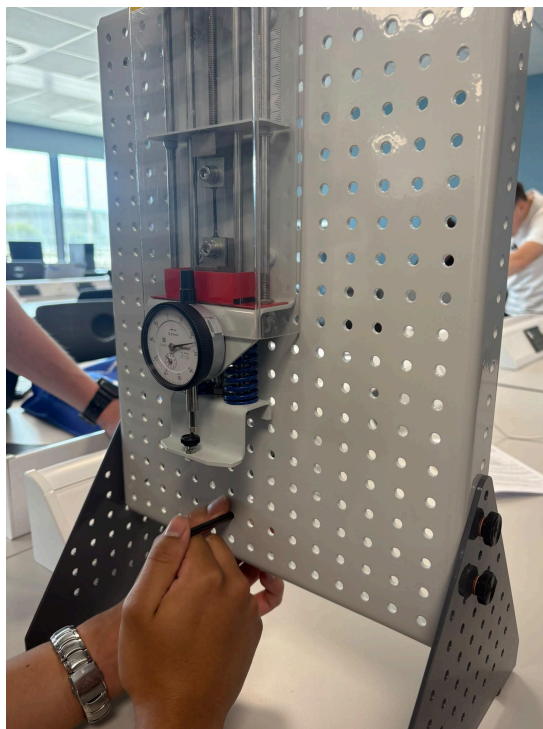
A tensile test measures a material's ability to resist tensile load as well as how that changes as it's stretched. The testing is done by applying force to the material until it reaches its fracture point, the point which it breaks. During this process the amount the material has stretched is recorded. From this the materials ultimate tensile stress, the maximum stress the material can hold, can be acquired as well as its elastic limit, the limit of elastic deformation (Michigan Technological University).

Experiment Procedure

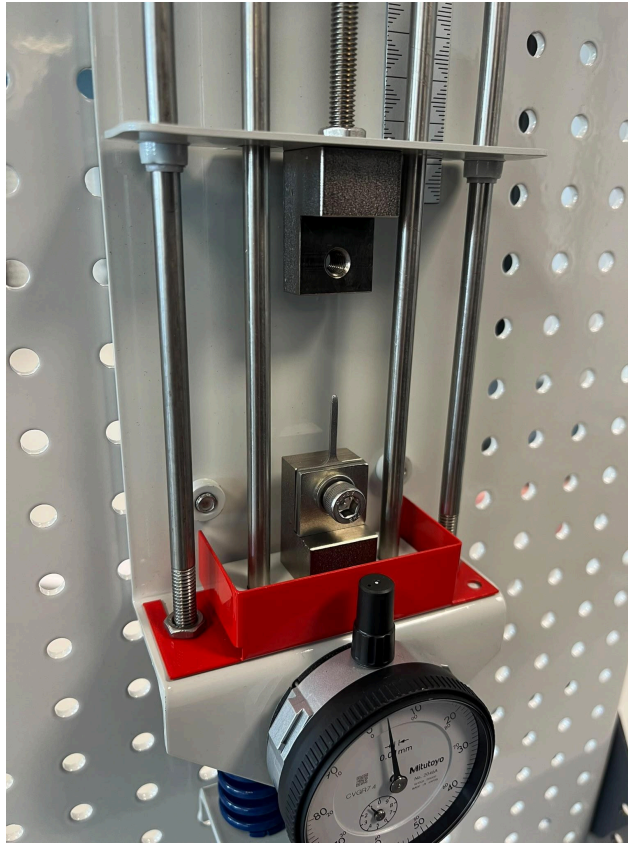
Initially the first sample of steel was installed in the test machine.



The tensioning screw was then tightened to the first data point on the datasheet and the reading on the dial indicator was recorded.



The tensioning screw was then adjusted to the next datapoint and another reading was taken. This was repeated until the sample broke.



This was all then repeated for a sample of aluminium, duraluminium and PVC.

Results and Analysis

All the materials had a gage length of 31mm, a width of 2mm and a depth of 1mm making a cross sectional area of 0.000002m^2 . All experiments were performed at 24°C .

Steel

The results of the test as well as calculated stress and strain are displayed in Figure 1.1

Load(mm)	Dial indicator(mm)	Force(N)	Extensio n(mm)	Nominal Strain	Stress (Pa)
0	0	0	0	0	0
0.2	0.1	10	0.1	0.003225 806452	5000000 000
0.4	0.26	26	0.14	0.004516 129032	1300000 0000
0.6	0.46	46	0.14	0.004516 129032	2300000 0000
0.8	0.65	65	0.15	0.004838 709677	3250000 0000

1	0.84	84	0.16	0.005161 290323	4200000 0000
1.2	1.02	102	0.18	0.005806 451613	5100000 0000
1.4	1.21	121	0.19	0.006129 032258	6050000 0000
1.6	1.39	139	0.21	0.006774 193548	6950000 0000
1.8	1.59	159	0.21	0.006774 193548	7950000 0000
2	1.77	177	0.23	0.007419 354839	8850000 0000
2.2	1.91	191	0.29	0.009354 83871	9550000 0000
2.4	2.15	215	0.25	0.008064 516129	1075000 00000
2.6	2.33	233	0.27	0.008709 677419	1165000 00000
2.8	2.53	253	0.27	0.008709 677419	1265000 00000
3	2.72	272	0.28	0.009032 258065	1360000 00000
3.2	2.9	290	0.3	0.009677 419355	1450000 00000
3.4	3.08	308	0.32	0.010322 58065	1540000 00000
3.6	3.26	326	0.34	0.010967 74194	1630000 00000
3.8	3.44	344	0.36	0.011612 90323	1720000 00000
4	3.6	360	0.4	0.012903 22581	1800000 00000
4.2	3.73	373	0.47	0.015161 29032	1865000 00000
4.4	3.86	386	0.54	0.017419 35484	1930000 00000
4.6	4.12	412	0.48	0.015483 87097	2060000 00000
4.8	4.24	424	0.56	0.018064 51613	2120000 00000
5	4.37	437	0.63	0.020322 58065	2185000 00000
6	4.91	491	1.09	0.035161 29032	2455000 00000
7	5.36	536	1.64	0.052903 22581	2680000 00000

8	5.68	568	2.32	0.074838 70968	2840000 00000
9	5.89	589	3.11	0.100322 5806	2945000 00000
10	6.1	610	3.9	0.125806 4516	3050000 00000

Figure 1.1

The graph of stress and strain is plotted in figure 1.2 and the graph for stress against strain in the hooks law obeying region is shown in figure 1.3

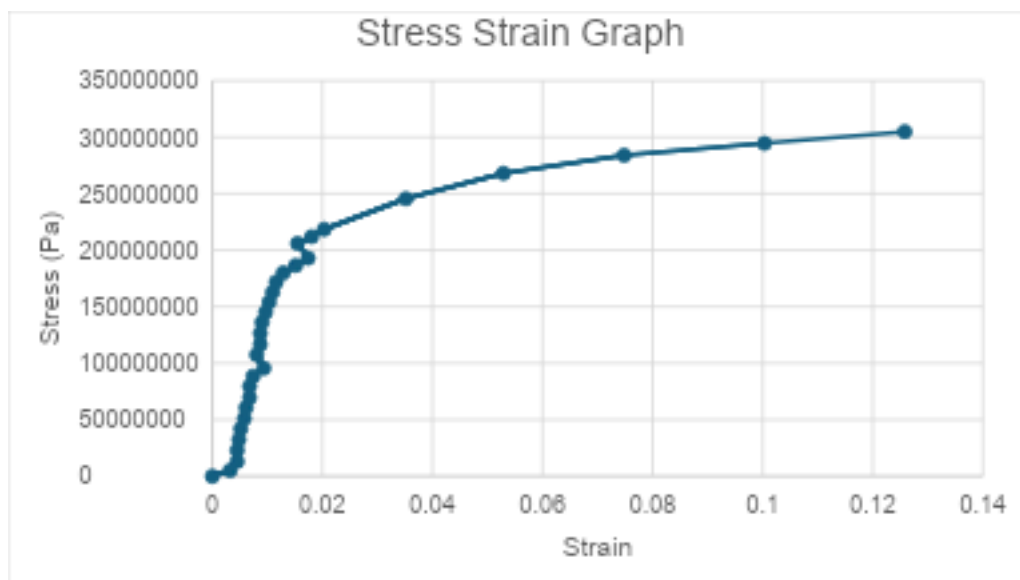


Figure 1.2

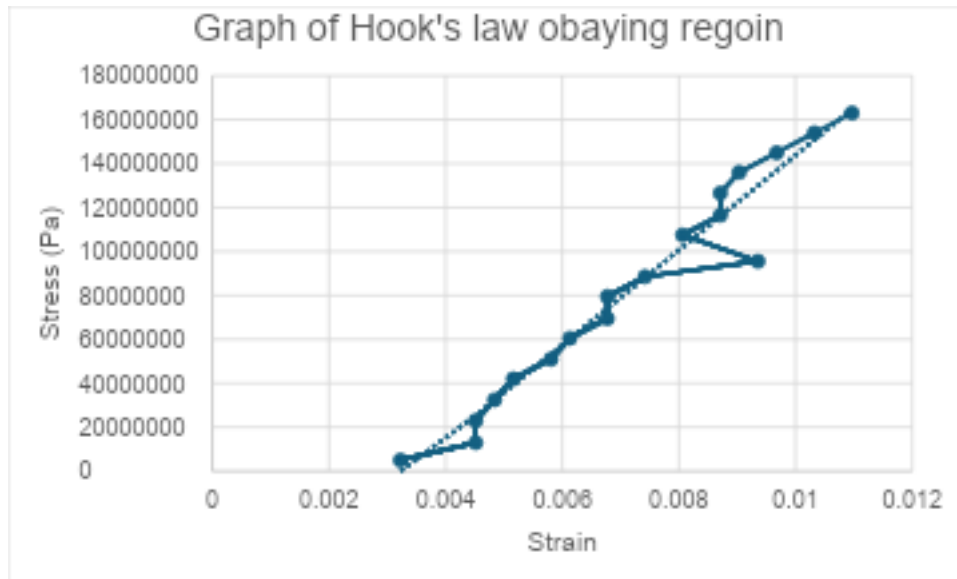


Figure 1.3

From this data we can see that the nominal young's modulus for steel is 20GPa, the ultimate tensile strength was 310MPa and the elastic limit was 163MPa. The steel stretched to a new length of 35mm giving an elongation of 13%.

Aluminium

The results of the test as well as calculated stress and strain are displayed in Figure 2.1

Load	dial indicator	force (N)	extension	nominal strain	stress
0	0	0	0	0	0
0.2	0.2	20	0	0	1000000
0.4	0.36	36	0.04	0.00129	1800000
0.6	0.54	54	0.06	0.00193	2700000
0.8	0.7	70	0.1	0.00322	3500000
1	0.87	87	0.13	0.00419	4350000
1.2	1.05	105	0.15	0.00483	5250000

				0.00580	6100000
1.4	1.22	122	0.18	6	0
				0.00580	7100000
1.6	1.42	142	0.18	6	0
				0.00774	7800000
1.8	1.56	156	0.24	2	0
				0.00838	8700000
2	1.74	174	0.26	7	0
				0.00935	9550000
2.2	1.91	191	0.29	5	0
				0.01032	1.04E+0
2.4	2.08	208	0.32	3	8
				0.01096	1.13E+0
2.6	2.26	226	0.34	8	8
					1.25E+0
2.8	2.49	249	0.31	0.01	8
				0.01258	1.31E+0
3	2.61	261	0.39	1	8
				-0.0164	1.86E+0
3.2	3.71	371	-0.51	5	8
3.4	3.8	380	-0.4	-0.0129	1.9E+08
				0.02387	1.43E+0
3.6	2.86	286	0.74	1	8
				0.02709	1.48E+0
3.8	2.96	296	0.84	7	8
					1.52E+0
4	3.03	303	0.97	0.03129	8
				0.03580	1.55E+0
4.2	3.09	309	1.11	6	8
				0.04096	1.57E+0
4.4	3.13	313	1.27	8	8
				0.04580	1.59E+0
4.6	3.18	318	1.42	6	8
				0.05193	
4.8	3.19	319	1.61	5	1.6E+08
				0.05774	1.61E+0
5	3.21	321	1.79	2	8

Figure 2.1

The graph of stress and strain is plotted in figure 2.2 and the graph for stress against strain in the hooks law obeying region is shown in figure 2.3

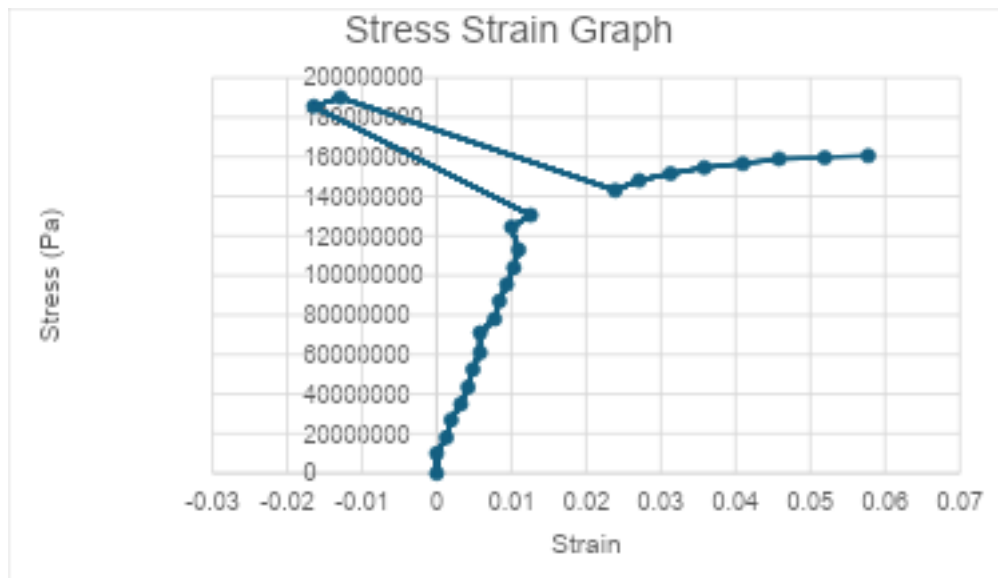


Figure 2.2

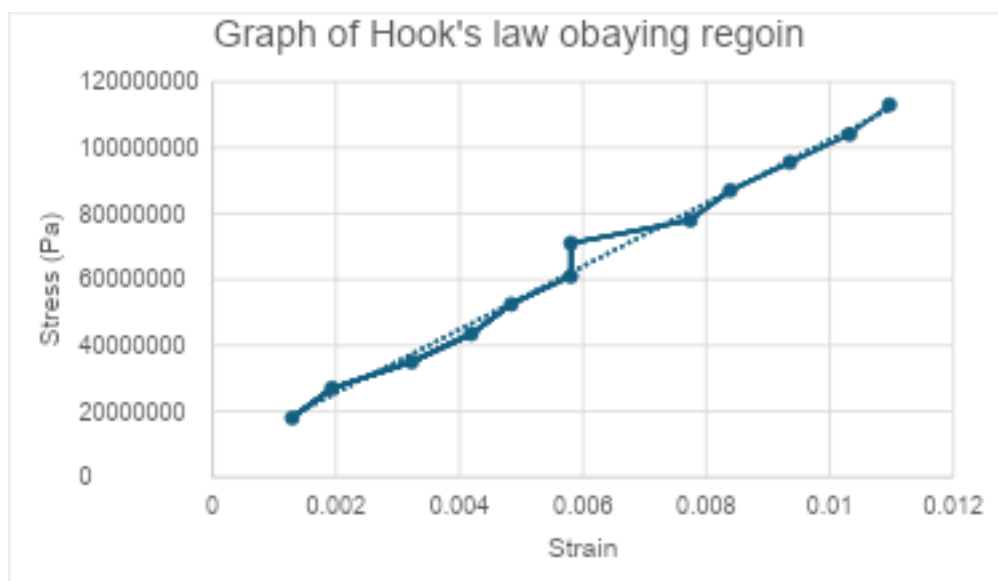


Figure 2.3

From this data we can see that the nominal youngs modulus for aluminium is 10GPa, the ultimate tensile strength was 190MPa and the elastic limit was 113MPa. The aluminium stretched to a new length of 34mm giving an elongation of 10%.

Duralumin

The results of the test as well as calculated stress and strain are displayed in Figure 3.1

Load	dial indicator	force	extension	Nominal strain	stress
0	0	0	0	0	0
				0.00258	
0.2	0.12	12	0.08	1	6000000
				0.00451	1300000
0.4	0.26	26	0.14	6	0
				0.00580	2100000
0.6	0.42	42	0.18	6	0
				0.00677	2950000
0.8	0.59	59	0.21	4	0
				0.00709	3900000
1	0.78	78	0.22	7	0
				0.00774	4800000
1.2	0.96	96	0.24	2	0
					5650000
1.4	1.13	113	0.27	0.00871	0
				0.00935	6550000
1.6	1.31	131	0.29	5	0
				0.01032	7400000
1.8	1.48	148	0.32	3	0
				0.01064	8350000
2	1.67	167	0.33	5	0
				0.01161	9200000
2.2	1.84	184	0.36	3	0
				0.00806	1.08E+0
2.4	2.15	215	0.25	5	8
					1.17E+0
2.6	2.33	233	0.27	0.00871	8
				0.00935	1.26E+0
2.8	2.51	251	0.29	5	8
				0.01032	1.34E+0
3	2.68	268	0.32	3	8
				0.01096	1.43E+0
3.2	2.86	286	0.34	8	8
				0.01161	1.52E+0
3.4	3.04	304	0.36	3	8
				0.01225	1.61E+0
3.6	3.22	322	0.38	8	8
				0.01258	1.71E+0
3.8	3.41	341	0.39	1	8
				0.01322	
4	3.59	359	0.41	6	1.8E+08
				0.01387	1.89E+0
4.2	3.77	377	0.43	1	8
				0.01451	1.98E+0
4.4	3.95	395	0.45	6	8

				0.01516	2.07E+0
4.6	4.13	413	0.47	1	8
				0.01580	2.16E+0
4.8	4.31	431	0.49	6	8
				0.01967	
5	4.39	439	0.61	7	2.2E+08
				0.01612	2.75E+0
6	5.5	550	0.5	9	8
				0.04354	2.83E+0
7	5.65	565	1.35	8	8

Figure 3.1

The graph of stress and strain is plotted in figure 3.2 and the graph for stress against strain in the hooks law obeying region is shown in figure 3.3

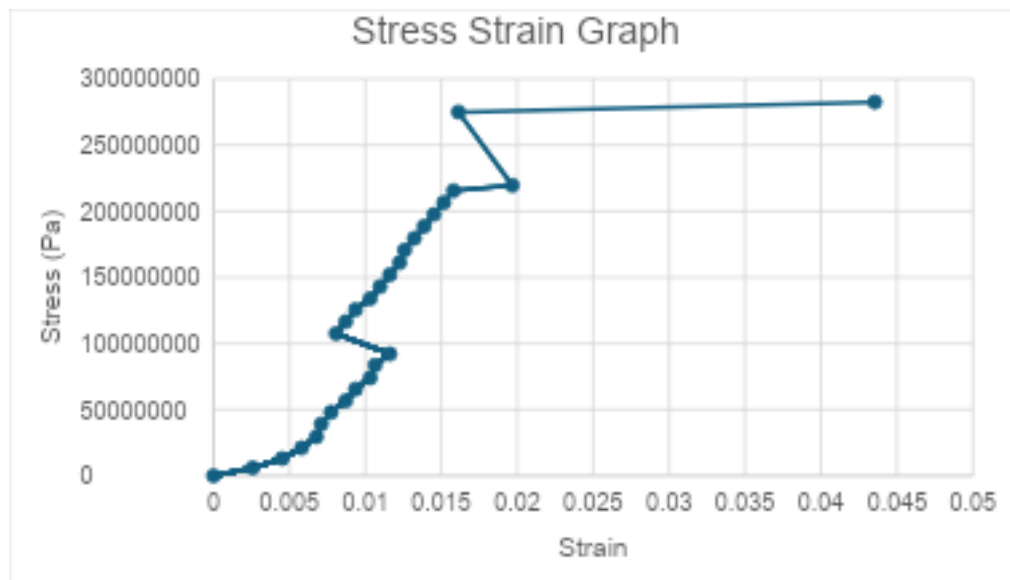


Figure 3.2

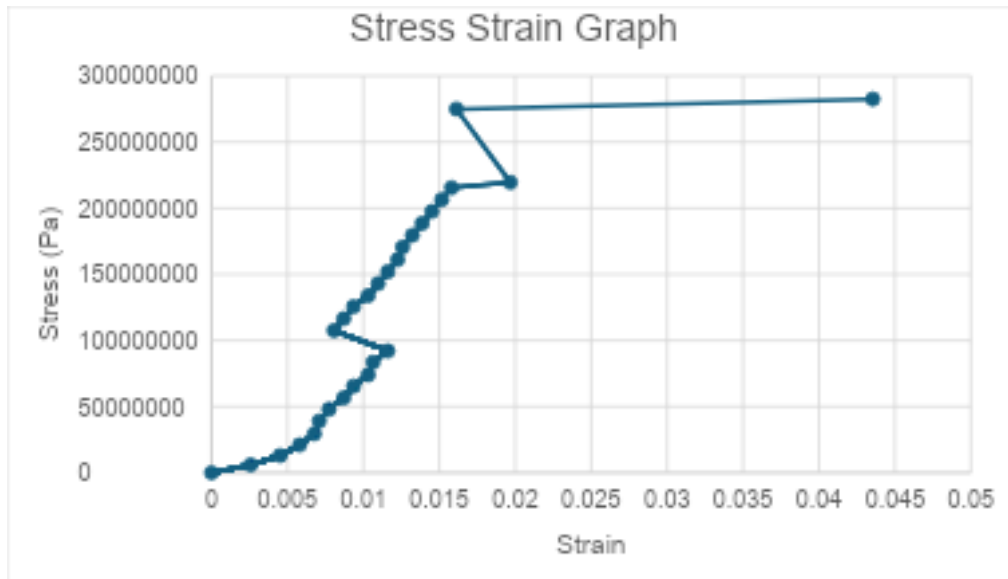


Figure 3.3

From this data we can see that the nominal young's modulus for Duralumin is 20GPa, the ultimate tensile strength was 283MPa and the elastic limit was 216MPa. The Duralumin stretched to a new length of 33mm giving an elongation of 6%

PVC

The results of the test as well as calculated stress and strain are displayed in Figure 4.1

Load	dial indicator	force (N)	extension	Nominal strain	stress
0	0	0	0	0	0
0.2	0.07	7	0.13	0.00419	3500000
0.4	0.16	16	0.24	0.00774	8000000
0.6	0.25	25	0.35	0.01129	12500000
0.8	0.33	33	0.47	0.01516	16500000
1	0.42	42	0.58	0.01871	21000000
1.2	0.5	50	0.7	0.02258	25000000

				0.02709	2800000
1.4	0.56	56	0.84	7	0
				0.03322	2850000
1.6	0.57	57	1.03	6	0
				0.04387	2200000
1.8	0.44	44	1.36	1	0
				0.05161	2000000
2	0.4	40	1.6	3	0
				0.05806	2000000
2.2	0.4	40	1.8	5	0
				0.06451	2000000
2.4	0.4	40	2	6	0
				0.07096	2000000
2.6	0.4	40	2.2	8	0
				0.07709	2050000
2.8	0.41	41	2.39	7	0
				0.08354	2050000
3	0.41	41	2.59	8	0
					2050000
3.2	0.41	41	2.79	0.09	0
				0.09645	2050000
3.4	0.41	41	2.99	2	0
				0.10290	2050000
3.6	0.41	41	3.19	3	0
				0.10935	2050000
3.8	0.41	41	3.39	5	0
				0.11580	2050000
4	0.41	41	3.59	6	0
				0.12225	2050000
4.2	0.41	41	3.79	8	0
					2050000
4.4	0.41	41	3.99	0.12871	0
				0.13516	2050000
4.6	0.41	41	4.19	1	0
				0.14161	2050000
4.8	0.41	41	4.39	3	0
				0.14516	2500000
5	0.5	50	4.5	1	0
				0.17935	2200000
6	0.44	44	5.56	5	0
				0.21193	2150000
7	0.43	43	6.57	5	0
				0.24516	2000000
8	0.4	40	7.6	1	0

Figure 4.1

The graph of stress and strain is plotted in figure 4.2 and the graph for stress against strain in the hooks law obeying region is shown in figure 4.3

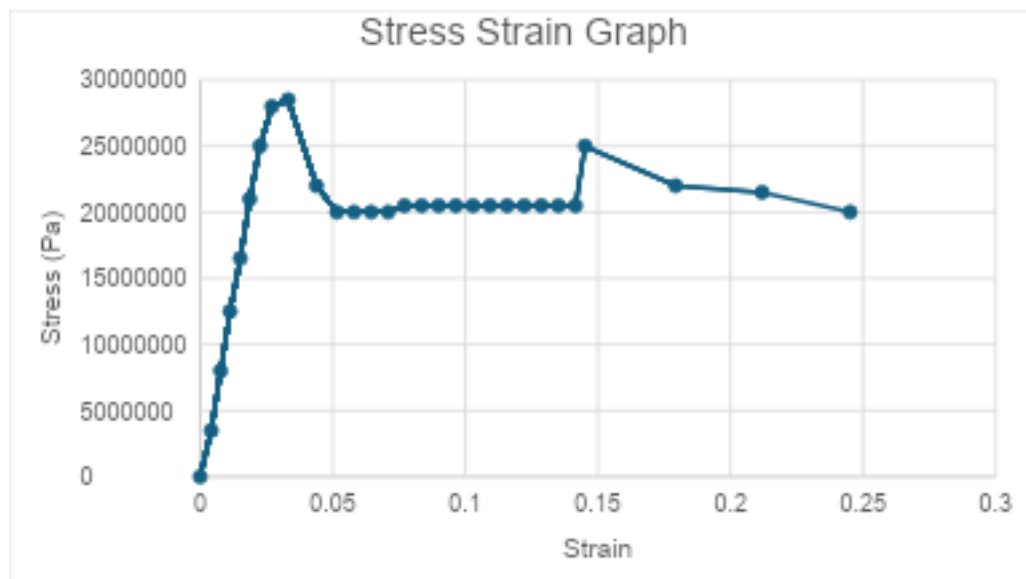


Figure 4.2

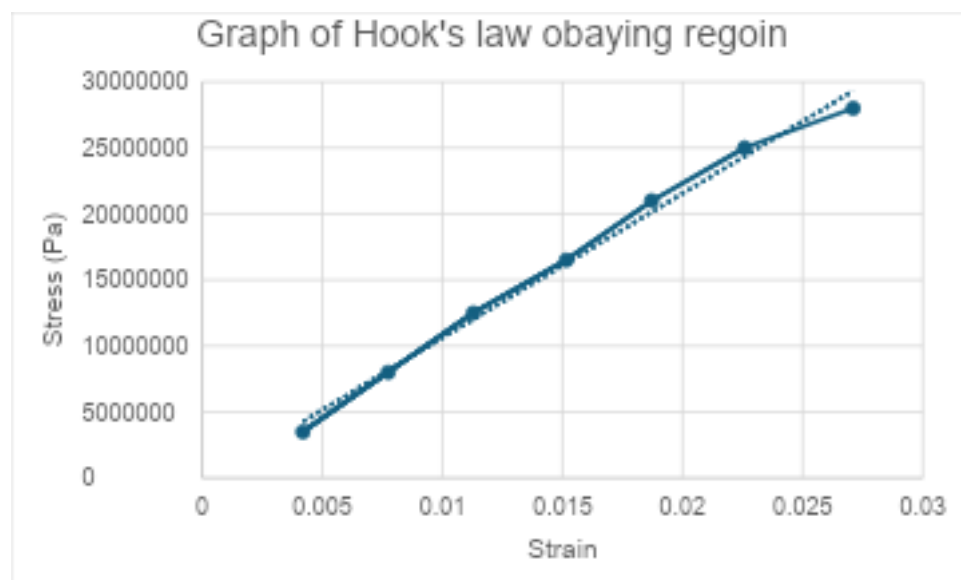


Figure 4.3

From this data we can see that the nominal young's modulus for PVC is 1GPa, the ultimate tensile strength was 28.5MPa and the elastic limit was 28MPa. The PVC stretched to a new length of 39mm giving an elongation of 26%

Conclusion

Steel

The tested results for steel states an Ultimate tensile strength of 310MPa and an elastic limit (or yield stress) of 163MPa. According to MatWeb a general steel should have an ultimate tensile strength of 420MPa and an elastic limit of 350MPa (MatWeb). The results in the experiment are lower than in the online data. This could be caused by a difference in tested steels or the test rig itself stretching.

Aluminium

The tested results for aluminum states an Ultimate tensile strength of 190MPa and an elastic limit (or yield stress) of 113MPa. According to ASM Aerospace a general aluminium should have an ultimate tensile strength of 310MPa and an elastic limit of 276MPa (ASM Aerospace). The results in the experiment are lower than in the online data. This could be caused by a difference in tested aluminium or the test rig itself stretching.

Duralumin

The tested results for duralumin states an Ultimate tensile strength of 283MPa and an elastic limit (or yield stress) of 216MPa. According to an online paper a general duralumin should have an ultimate tensile strength of 720MPa and an elastic limit of 450MPa (Chintalapudi et al). The results in the experiment are lower than in the online data. This could be caused by a difference in tested duralumin or the test rig itself stretching.

PVC

The tested results for duralumin states an Ultimate tensile strength of 28.5MPa and an elastic limit (or yield stress) of 28MPa. According to MatWeb a general duralumin should have an ultimate tensile strength of 14.3-55.2 MPa and an elastic limit of 3.45-73.1MPa (MatWeb). The results in the experiment are within the range of the online data.

Evaluation

During the experiment an effort was made to reduce errors as much as possible. This was done by taking many small measurements as well as recording environmental factors such as temperature. In the analysis process, errors were reduced by ignoring the first few results as there was a consistent zero error. Despite this human error in the experiment played a huge factor in the results. Furthermore, the test rig was likely stretching as the results generated under high load were inaccurate compared to online results.

Further Work

Given an unlimited budget the experiment could be made better by using a computer to take measurements in order to remove human error as well as have the zero error calibrated for. Finally, the test rig should have it's ability to stretch under force calibrated for so it doesn't skew results.,

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