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TENSILE STRENGTH TEST

Due - Sunday 8th December 2024

Programme and Module

BEng, HND & HNC Automotive, Motorcycle & Motorsport Engineering
Engineering Science
Module Code – ACHA4002 & ACMA4028

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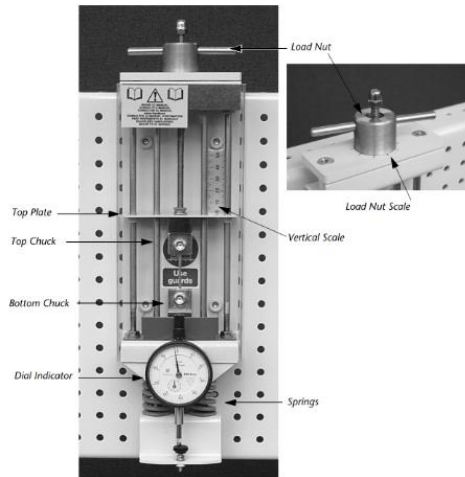
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Chapter 1 - Introduction

This technical report was created after conducting a tensile strength test. This is used to measure a material's ability to withstand pulling forces; tension. Furthermore, tests were conducted on four materials: mild steel, aluminium, duralumin and PVC plastic. The purpose of the tests was to unveil the materials different behaviours of the forces being applied to them, as well as analyse the yield strength and ultimate tensile strength of each material.

Chapter 2 – Experimental Procedure

The tensile tester is small, compact and User-friendly. Firstly, it utilises two chucks that are used to hold the sample material in place. A Load Nut, which is situated at the top of the tester, is used to pull the top chuck upwards, meaning that the sample material is stretched by 1mm, for each complete turn.

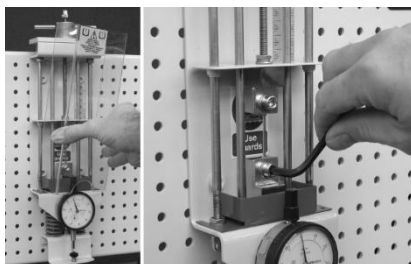


Furthermore, the Load Nut has a small groove and a scale which is divided into 10 segments. Its purpose is to help the user track how many turns they have completed, with each increment showing a stretch of 0.1mm. The bottom chuck is connected to two large springs and a Dial Indicator is used to measure the deflection of the two springs, when force is applied to the material.

Additionally, the top plate uses a vertical scale, which is used to monitor how many turns the user has completed, for example; one turn is equal to 1mm.

Figure 1: Layout of the Tensile Tester

(TecQuipment, 2012)



To remove or replace a material sample, first remove the safety guard. Then, using a Hex/Allen key, undo the two M10 bolts, retaining the sample.

To fit a new material sample, the load nut will need to be returned to its original position, as the chucks will be too far apart and the sample will not fit. Next, it is important that the safety guard is refitted.

Figure 2: Removing/replacing sample material and safety guard

(TecQuipment, 2012)



On top of that. Next, turn the dial indicator until it tensions and shows signs of movement, while also making sure that the notch of the Force Control aligns any of the ten marks on its circular scale.

Finally, make sure to turn the dial indicators outer bezel, meaning it should align with zero.

Figure 3: Setting the dial indicator to zero

(TecQuipment, 2012)

Chapter 3 – Results

Figure 4: Steel Data Collected

Steel Raw Data	
Load Nut Movement (mm)	Dial Indicator (mm)
0	0
0.2	0.17
0.4	0.35
0.6	0.54
0.8	0.72
1	0.91
1.2	1.1
1.4	1.29
1.6	1.47
1.8	1.65
2	1.85
2.2	2.04
2.4	2.22
2.6	2.41
2.8	2.58
3	2.76
3.2	2.92
3.4	3.07
3.6	3.2
3.8	3.3
4	3.46
4.2	3.57
4.4	3.7
4.6	3.81
4.8	3.92
5	4.05
6	4.53
7	4.87
8	5.13
9	5.32
10	5.4
Original Length:	30.8mm
Final Length:	38.4mm
Cross Sectional Height:	2mm
Cross Sectional Area:	0.9mm

Figure 5: Aluminium Data Collected

Aluminium Raw Data	
Load Nut Movement (mm)	Dial Indicator (mm)
0	0
0.2	0.16
0.4	0.33
0.6	0.51
0.8	0.67
1	0.76
1.2	0.91
1.4	1.07
1.6	1.24
1.8	1.39
2	1.52
2.2	1.7
2.4	1.86
2.6	2
2.8	2.1
3	2.21
3.2	2.3
3.4	2.4
3.6	2.47
3.8	2.56
4	2.58
4.2	2.67
4.4	2.72
4.6	2.74
4.8	2.79
Original Length:	31.0mm
Final Length:	35.8mm
Cross Sectional Height:	2mm
Cross Sectional Area:	0.9mm

Figure 6: Duralumin Data Collected

Duralumin Raw Data	
Load Nut Movement (mm)	Dial Indicator (mm)
0	0
0.2	0.16
0.4	0.33
0.6	0.51
0.8	0.66
1	0.79
1.2	0.97
1.4	1.12
1.6	1.27
1.8	1.44
2	1.61
2.2	1.78
2.4	1.96
2.6	2.14
2.8	2.31
3	2.47
3.2	2.66
3.4	2.82
3.6	2.99
3.8	3.12
4	3.34
4.2	3.51
4.4	3.68
4.6	3.85
4.8	4.02
5	4.18
6	4.76
7	5
8	5.12
Original Length:	31.0mm
Final Length:	33.7mm
Cross Sectional Height:	2mm
Cross Sectional Area:	1mm

Figure 7: PVC Plastic Data Collected

PVC Plastic Raw Data	
Load Nut Movement (mm)	Dial Indicator (mm)
0	0
0.2	0.03
0.4	0.08
0.6	0.12
0.8	0.17
1	0.23
1.2	0.28
1.4	0.31
1.6	0.18
1.8	0.22
2	0.23
2.2	0.2
2.4	0.21
2.6	0.21
2.8	0.21
3	0.2
3.2	0.2
3.4	0.2
3.6	0.2
3.8	0.2
4	0.2
4.2	0.2
4.4	0.2
4.6	0.2
4.8	0.2
5	0.2
6	0.19
7	0.24
8	0.25
9	0.25
10	0.22
20	0.16
30	0.17
40	0.16
Original Length:	31.0mm
Final Length:	68.6mm
Cross Sectional Height:	2mm
Cross Sectional Area:	1mm

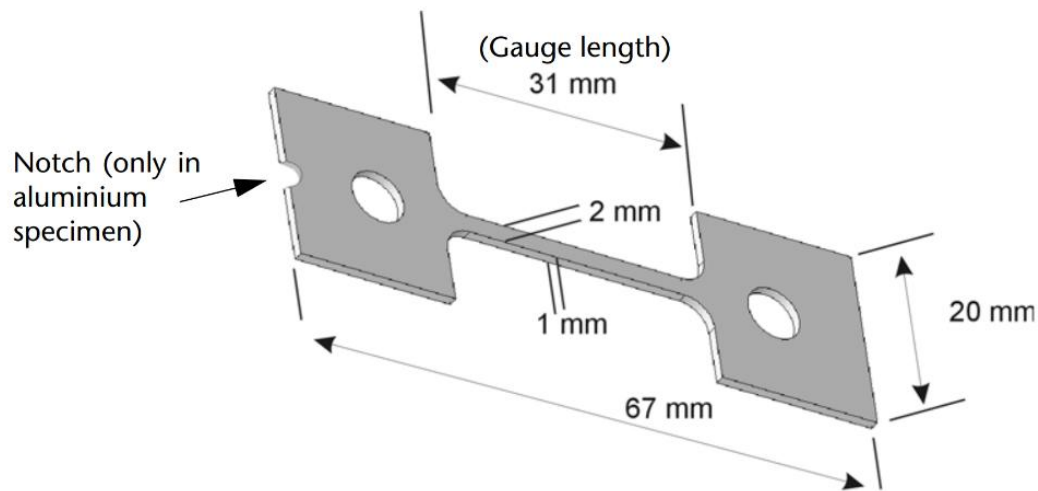


Figure 8: Material Sample Dimensions

(TecQuipment, n.d.)

A vernier calliper was used to precisely measure the dimensions of the sample materials, including, the original length, final length, cross-sectional height, and cross-sectional area. Furthermore, this meant that readings for the tensile strength test were accurate and fair for further analysis. Next, the tensile strength test could then be undertaken, which included gradually applying force in specific increments to the material samples, until they broke. Monitoring the dial indicator meant that the applied force and elongation could be tracked at the specific increments. Finally, the data collected, were systematically recorded in an Excel spreadsheet for further analysis.

Chapter 4 – Analysis

Measurement:	Formula:	Source:
Force (N)	Dial Indicator (mm) x 100	(TecQuipment, 2012)
Extension (mm)	Load Nut Movement (mm) - Dial Indicator (mm)	(TecQuipment, 2012)
Stress (MN/m ²)	Force (N) / Cross Sectional Area (m ²) / 1000000	(Toppr-guides, 2019)
Nominal Strain	Extension (mm) / Original Length (mm)	(Toppr-guides, 2019)
Tensile Strength (MN/m ²)	Ultimate Force (N) / Cross Sectional Area (m ²) / 1000000	(Calculatorultra.com, 2024)
Yield Stress (N/m ²)	“Stops deforming elastically and starts deforming plastically”	(www.xometry.com, n.d.)
Percentage Elongation	Final Length (mm) - Original Length (mm) / Original Length (mm) x 100	(Calculatorultra.com, 2024)
Young's Modulus E (GPa)	Ultimate Stress / Ultimate Nominal Strain at Ultimate Stress	(Toppr-guides, 2019)

Steel Under Tension					
Load Nut Movement (mm)	Dial Indicator (mm)	Force (N)	Extension (mm)	Stress (MN/m ²)	Nominal Strain
0	0	0	0	0.00	0.000000
0.2	0.17	17	0.03	9.44	0.000974
0.4	0.35	35	0.05	19.44	0.001623
0.6	0.54	54	0.06	30.00	0.001948
0.8	0.72	72	0.08	40.00	0.002597
1	0.91	91	0.09	50.56	0.002922
1.2	1.1	110	0.1	61.11	0.003247
1.4	1.29	129	0.11	71.67	0.003571
1.6	1.47	147	0.13	81.67	0.004221
1.8	1.65	165	0.15	91.67	0.004870
2	1.85	185	0.15	102.78	0.004870
2.2	2.04	204	0.16	113.33	0.005195
2.4	2.22	222	0.18	123.33	0.005844
2.6	2.41	241	0.19	133.89	0.006169
2.8	2.58	258	0.22	143.33	0.007143
3	2.76	276	0.24	153.33	0.007792
3.2	2.92	292	0.28	162.22	0.009091
3.4	3.07	307	0.33	170.56	0.010714
3.6	3.2	320	0.4	177.78	0.012967
3.8	3.3	330	0.5	183.33	0.016234
4	3.46	346	0.54	192.22	0.017532
4.2	3.57	357	0.63	198.33	0.020455
4.4	3.7	370	0.7	205.56	0.022727
4.6	3.81	381	0.79	211.67	0.025649
4.8	3.92	392	0.88	217.78	0.028571
5	4.05	405	0.95	225.00	0.030844
6	4.53	453	1.47	251.67	0.047727
7	4.87	487	2.13	270.56	0.069156
8	5.13	513	2.87	285.00	0.093182
9	5.32	532	3.68	295.56	0.119481
10	5.4	540	4.6	300.00	0.149351

Original Length (mm)	30.8
Final Length (mm)	38.4
Cross Sectional Area (m ²)	0.0000018

Tensile Strength (MN/m ²)	300
Yield Stress (MN/m ²)	170.56
Percentage Elongation	24.68
Young's Modulus E (GPa)	15.92

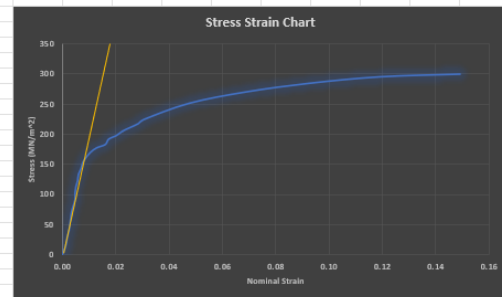
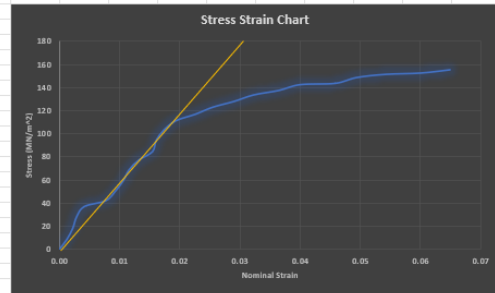


Figure 9: Steel Analysis Data

When undertaking the tensile strength test of steel, the material peaked with an elastic limit and yield point of 170.56 N/m² and a nominal strain of 0.01. At this point, the material began to transition from elastic deformation to the plastic region. In the plastic region, the mild steel sample is no longer able to return to its original shape, meaning when the load is removed, there is permanent deformation. This is shown as the original length of the sample was measured at 30.8mm and its final length before breaking was 38.4mm.

Aluminium Under Tension					
Load Nut Movement (mm)	Dial Indicator (mm)	Force (N)	Extension (mm)	Stress (MN/m ²)	Nominal Strain
0	0	0	0	0.00	0.000000
0.2	0.16	16	0.04	8.89	0.001290
0.4	0.33	33	0.07	18.33	0.002258
0.6	0.51	51	0.09	28.33	0.002903
0.8	0.67	67	0.13	37.22	0.004194
1	0.76	76	0.24	42.22	0.007742
1.2	0.91	91	0.29	50.56	0.009355
1.4	1.07	107	0.33	59.44	0.010645
1.6	1.24	124	0.36	68.89	0.011613
1.8	1.39	139	0.41	77.22	0.013226
2	1.52	152	0.48	84.44	0.015484
2.2	1.7	170	0.5	94.44	0.016129
2.4	1.86	186	0.54	103.33	0.017419
2.6	2	200	0.6	111.11	0.019355
2.8	2.1	210	0.7	116.67	0.022581
3	2.21	221	0.79	122.78	0.025484
3.2	2.3	230	0.9	127.78	0.029032
3.4	2.4	240	1	133.33	0.032258
3.6	2.47	247	1.13	137.22	0.036452
3.8	2.56	256	1.24	142.22	0.040000
4	2.58	258	1.42	143.33	0.045806
4.2	2.67	267	1.53	148.33	0.049355
4.4	2.72	272	1.68	151.11	0.054194
4.6	2.74	274	1.86	152.22	0.060000
4.8	2.79	279	2.01	155.00	0.064839



Original Length (mm)	31
Final Length (mm)	35.8
Cross Sectional Area (m ²)	0.0000018

Tensile Strength (MN/m ²)	155
Yield Stress (MN/m ²)	111.11
Percentage Elongation	15.48
Young's Modulus E (GPa)	5.74

Figure 10: Aluminium Analysis Data

During the tensile strength test of aluminium, the material reached its elastic limit and yield point of 111.11 N/m² and a nominal strain of 0.19. After its elastic peak of 111.11 N/m² the aluminium sample changed from elastic deformation to the plastic region with a final nominal strain of 0.64. In the plastic region, the aluminium sample could no longer return to its original shape, resulting in permanent deformation. This was evident as the original length of the sample, measured at 31.0mm and increased to 35.8 mm before the material ultimately broke.

Duralumin Under Tension					
Load Nut Movement (mm)	Dial Indicator (mm)	Force (N)	Extension (mm)	Stress (MN/m ²)	Nominal Strain
0	0	0	0	0	0.000000
0.2	0.16	16	0.04	8	0.001290
0.4	0.33	33	0.07	16.5	0.002258
0.6	0.51	51	0.09	25.5	0.002903
0.8	0.66	66	0.14	33	0.004516
1	0.79	79	0.21	39.5	0.006774
1.2	0.97	97	0.23	48.5	0.007419
1.4	1.12	112	0.28	56	0.009032
1.6	1.27	127	0.33	63.5	0.010645
1.8	1.44	144	0.36	72	0.011613
2	1.61	161	0.39	80.5	0.012581
2.2	1.78	178	0.42	89	0.013548
2.4	1.96	196	0.44	98	0.014194
2.6	2.14	214	0.46	107	0.014839
2.8	2.31	231	0.49	115.5	0.015806
3	2.47	247	0.53	123.5	0.017097
3.2	2.66	266	0.54	133	0.017419
3.4	2.82	282	0.58	141	0.018710
3.6	2.99	299	0.61	149.5	0.019677
3.8	3.12	312	0.68	156	0.021935
4	3.34	334	0.66	167	0.021290
4.2	3.51	351	0.69	175.5	0.022258
4.4	3.68	368	0.72	184	0.023226
4.6	3.85	385	0.75	192.5	0.024194
4.8	4.02	402	0.78	201	0.025161
5	4.18	418	0.82	209	0.026452
6	4.76	476	1.24	238	0.040000
7	5	500	2	250	0.064516
8	5.12	512	2.88	256	0.092903

Original Length (mm)	31
Final Length (mm)	33.7
Cross Sectional Area (m ²)	0.000002

Tensile Strength (MN/m ²)	256
Yield Stress (MN/m ²)	209
Percentage Elongation	8.71
Young's Modulus E (GPa)	7.90

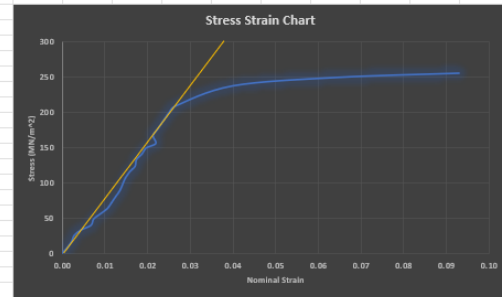
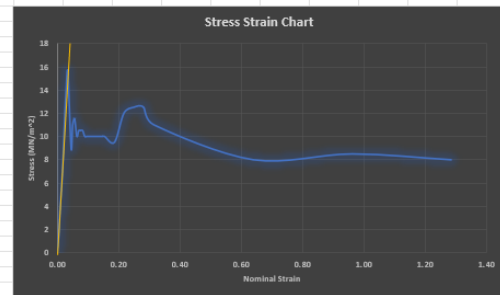


Figure 11: Duralumin Analysis Data

While conducting the tensile strength test of duralumin, the material experienced a maximum elastic limit and yield point of 209 N/m² with a nominal strain of 0.26. Beyond this point, the duralumin began to move into the plastic region, where it deformed permanently. The final nominal strain recorded was 0.92. This permanent deformation was evident as the sample, initially measuring 31.0 mm in length, stretched to 33.7 mm before breaking.

PVC Plastic Under Tension					
Load Nut Movement (mm)	Dial Indicator (mm)	Force (N)	Extension (mm)	Stress (MN/m ²)	Nominal Strain
0	0	0	0	0	0.000000
0.2	0.03	3	0.17	1.5	0.005484
0.4	0.08	8	0.32	4	0.010323
0.6	0.12	12	0.48	6	0.015484
0.8	0.17	17	0.63	8.5	0.020323
1	0.23	23	0.77	11.5	0.024839
1.2	0.28	28	0.92	14	0.029677
1.4	0.31	31	1.09	15.5	0.035161
1.6	0.18	18	1.42	9	0.045806
1.8	0.22	22	1.58	11	0.050968
2	0.23	23	1.77	11.5	0.057097
2.2	0.2	20	2	10	0.064516
2.4	0.21	21	2.19	10.5	0.070645
2.6	0.21	21	2.39	10.5	0.077097
2.8	0.21	21	2.59	10.5	0.083548
3	0.2	20	2.8	10	0.090323
3.2	0.2	20	3	10	0.096774
3.4	0.2	20	3.2	10	0.103226
3.6	0.2	20	3.4	10	0.109677
3.8	0.2	20	3.6	10	0.116129
4	0.2	20	3.8	10	0.122581
4.2	0.2	20	4	10	0.129032
4.4	0.2	20	4.2	10	0.135484
4.6	0.2	20	4.4	10	0.141935
4.8	0.2	20	4.6	10	0.148387
5	0.2	20	4.8	10	0.154839
6	0.19	19	5.61	9.5	0.187419
7	0.24	24	6.76	12	0.218065
8	0.25	25	7.75	12.5	0.250000
9	0.25	25	8.75	12.5	0.282258
10	0.22	22	9.78	11	0.315484
20	0.16	16	19.84	8	0.640000
30	0.17	17	29.83	8.5	0.962258
40	0.16	16	39.84	8	1.285161



Original Length (mm)	31
Final Length (mm)	68.6
Cross Sectional Area (m ²)	0.000002
Tensile Strength (MN/m ²)	8
Yield Stress (MN/m ²)	15.5
Percentage Elongation	121.29
Young's Modulus E (GPa)	0.44

Figure 12: PVC Plastic Analysis Data

In the process of testing the tensile strength of PVC plastic, the material experienced a maximum elastic limit and yield point of 15.5 N/m² with a nominal strain of 0.03. After this stage, the PVC plastic transitioned into the plastic region, undergoing permanent deformation. However, unlike the other materials, the PVC plastic didn't have a smooth plastic region. The results show a fluctuation until a nominal strain of 0.64. Furthermore, the material plateaued at this point until it ultimately broke, with a final strain of 1.28. The sample originally measured 31.0 mm in length, and a final length of 68.6 mm was recorded.

Chapter 5 – Conclusion

Through research, it is shown that mild steel has a yield stress of around 250 MPa and an ultimate tensile strength of approximately 400 MPa, before deformation and turning into the plastic region. In contrast, the material tested in this study had a yield stress of 170.56 MPa and an ultimate tensile strength of 300 MPa, both values are slightly lower than research indicated. Therefore, this would indicate that the steel in the study may have had reduced structural integrity. (Civil Sir, 2020)

Research conveys that aluminium has a yield stress of around 144 MPa and an ultimate tensile strength of approximately 151 MPa. However, the material tested in this study showed a yield stress of 111.11 MPa and an ultimate tensile strength of 155 MPa. The ultimate tensile strength values are very similar, however, the yield stress value in the study is slightly lower, when compared to research. (CNCLATHING, 2020)

Via research, findings indicate that duralumin has a yield stress of around 300 MPa and an ultimate tensile strength of roughly 450 MPa. In contrast, the material tested in this study exhibited a yield stress of 209 MPa and an ultimate tensile strength of 256 MPa, both lower than the typical values. This could be due to the use of a slightly different grade of duralumin. (Material Properties, 2021)

Research shows that PVC plastic does not have a distinct yield stress, however, it typically exhibits an ultimate tensile strength ranging from 7 MPa to 27 MPa. In contrast, the material tested in this study showed an ultimate tensile strength of 8 MPa and a yield strength of 15.5 MPa, which are within the lower end of the typical range for PVC. (matmake.com, n.d.)

Chapter 6 – Evaluation

To help eliminate errors when conducting the tensile strength test, precautions were implemented to establish accuracy and reliability. To start, the material samples are carefully measured and recorded, to make sure the test was fair, as there were some inconsistencies in sample lengths. Furthermore, testing equipment was reset and calibrated before each test, to guarantee accurate measurements. This included checking that the dial indicator read zero, and the notch of the Force Control pointed to one of the ten marks of its circular scale. Finally, each individual test was conducted at a steady, controlled rate of strain to ensure reliable data. Overall, all precautions and strategies, helped ensure that the results we accurate as possible.

Chapter 7 – Further work

When re-conducting the tensile strength test in the future, using a digital tensile tester would allow for more precise control over the force being applied, and would capture smaller changes in elongation and strain. Furthermore, a controlled temperature room, would make the test significantly fairer, as the properties of the materials are all different, meaning some are more fragile and brittle at lower temperatures. This controlled environment, would help ensure the test results are reliable. Finally, a smaller scale would enable smaller and finer increments, meaning each of the 10 segments on the Load Nut are more precise, meaning it would enhance the accuracy and precision of the results.

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