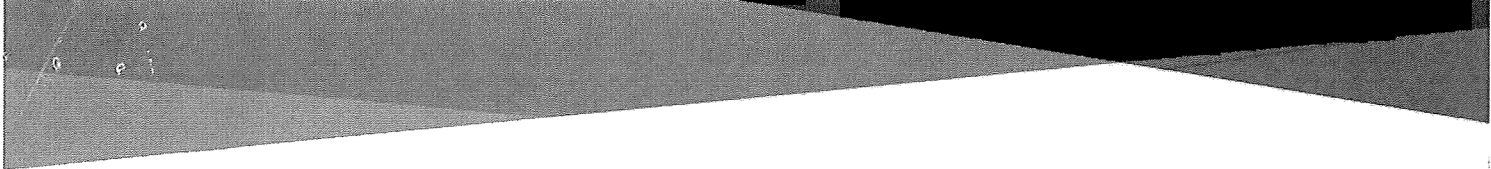


STUDENT FEEDBACK FORM (OSIAN MILLS)

This section details the *extent* to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement.

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills		
Engagement with a suitable range of literature, including sources retrieved independently. You did cover sufficient research to allow for the evaluation of results with many relevant points of interest identified. Some of your work needed more depth and scope. Referencing was missing throughout.	20	10
2. Knowledge and Understanding Skills		
Good knowledge of the underlying concepts and principles. Accurate and logical approach taken but somewhat descriptive at times. Your research needed further depth and scope and at times the terminology was at times confused. I would have liked to see more on the practical application of the theory covered.	30	17
3. Cognitive and Intellectual Skills		
A good attempt at the evaluation of the underlying concepts and principles. You did interpret the data correctly, and you demonstrated an ability to use evidence to support the argument. Some areas of the evaluation were underdeveloped (I would have liked to have seen more on flexural rigidity, for example).	20	12
4. Practical Application Skills		
Appropriate application of basic methods, materials, tools, and/or techniques. Clear appreciation of the context of the application. Good set of calculations, and reasonable values of E and G obtained. Beam stress calculation not attempted.	15	10
5. Transferable Skills for Life and Professional Practice		
Coherent, organised and accurate work in a suitable structure. Work is generally well written but descriptive at times. Referencing was not provided and needs to be improved in the future. Summary also good. You also need to ensure you use the correct tense and person is always used.	15	8

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)	%	57
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		



INVESTIGATION INTO ELASTIC CONSTANTS

Mechanical Engineering

Module code: SGEE4017
Submission Date: 10/12/2024

Mills, Osian

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INVESTIGATION INTO ELASTIC CONSTANTS

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Very good structure but a section numbering system was also needed.

Summary

The objective of the practical was to calculate the modulus of elasticity and modulus of rigidity of three materials. The modulus of elasticity was calculated on an aluminium beam and the modulus of rigidity was calculated on a 70/30 brass rod and a 0.4% carbon steel rod. To calculate the modulus of elasticity of the beam, a load was put onto the middle of the beam gradually. The results were taken and put into a table to create a graph, that is how we calculated the modulus of elasticity. This value was 67.2 GN/m^2 . For the modulus of rigidity both materials were put into a torsion testing rig. Torque was applied gradually, and the results were plotted into a table and then into graph. The results for the 30/70 brass rod were 67.33 GN/m^2 and the 0.4% carbon steel were 90.34 GN/m^2 . From this we can see that the 0.4% carbon steel would need much more torque for it to be deformed where as the 30/70 brass will deform under less force. When getting the theoretical values for the modulus of elasticity task you can see that the aluminium was quite accurate at a 68.9 GN/m^2 , with only a 1.2 GN/m^2 difference the practical was done correctly, possible rounding up errors or the load we used was incorrect. Whereas with the modulus of rigidity theoretical values, they were off quite a bit. With 70/30 brass being 40 GN/m^2 , which is a 27.33 GN/m^2 difference and the 0.4% carbon steel being 80 GN/m^2 , which is a 10.34 GN/m^2 difference. The rig that was used was not calibrated which could lead to an error in both values. The rod that was used as the 30/70 brass rod, it wasn't accurate as we did not know if that was the correct rod or not

A reasonable summary. Some terminology needed to be more technical.

Introduction

Remember to use third person

In this assignment I will investigate into elastic constants and see the way different materials are affected. To complete this I will be doing a total of 3 different practical tests which consist of 1 test of the effects of loading on a beam, and 2 tests on effects of torsion on cylindrical rods. From these tests I will be calculating young's modulus and modulus of rigidity of the material being used.

Objectives

Effects of loading on a beam

The objective of the first is to create a table from the results and plot a graph from these results. From the graph I can then the slope of graph, this is needed to calculate young's modulus (E).

Effects of torsion on cylindrical rods

The objective of this test is to calculate the modulus of rigidity (G) for the materials, to do this I first plotted the results into a table and then put them from the table into a graph. From the graph I can get the slope of the graph, and this is needed to calculate the modulus of rigidity (G).

Method

Effects of loading on a beam

To complete this test, I had an aluminium beam which was 800mm in length, 32mm wide and 5mm thick. The beam was put in the test rig and a load was applied to the beam progressively at the centre point. At each point I recorded the results, and they were put into a table. I then took the results and put them into excel, using excel I can create a line graph. After creating the graph, I can then calculate the young's modulus.

Effects of torsion on cylindrical rods

For this test I had used two different cylindrical rods. The rods used was a 0.4% carbon steel and a 30/60 brass, both rods were 90-mm in length and 5mm in diameter. The load was applied to the centre of both rods. One at a time the rods were put into a torsion testing rig, the load is applied to the rods by a worm and wheel drive and the torque are measured by a torque arm and spring balance. The angle of twist is measured with circular protractors. I recorded the values of angle of twist against applied torque into a table for both rods. Once both tables were filled, I put the results into excel to create a line graph for both results. Once I had the graph, I could calculate the modulus of rigidity for both materials.

Theory

Elastic constants

There are 4 different forms of elastic constants, these consists of young's modulus (E), modulus of rigidity (G), poisons ratio (ν) and bulk modulus (K). Of these 4 the two we used for this assignment was young's modulus and modulus of rigidity. Elastic constants came from Hooke's law.

Reference needed.

Youngs modulus (E)

Youngs modulus otherwise known as modulus of elasticity, gives us the ability to know when a material will bend or break. It is the property of the material that tells us how easily it can stretch and deform, it is defined as the ratio of tensile stress to tensile strain. Youngs modulus is very important as it is used to predict the behaviour of materials when subjected to force, it is important to limit the elastic deformation of a material to as small as possible.

You could have considered a typical value for aluminium.

Reference needed

Modulus of rigidity (G)

Modulus or rigidity is also known as shear modulus. This is used to measure the rigidity of a given material. It is the ratio of shear stress to shear strain, and it measures the elastic shear stiffness of a material. Modulus of rigidity can be determined through a torsion test for isotropic materials.

Again, you could have considered typical values for brass and steel.

Poissons ratio (ν)

Poissons ratio is like young's modulus, it is a material specific and independent constant. It describes how different material perform under load. Poison ratio is defined as the ratio of the lateral strain to the longitudinal strain, meaning that when a material is pulled in one direction, it gets compressed in the other direction.

Bulk modulus (K)

Bulk modulus describes the elastic properties of a material when it is under pressure on all surfaces. When pressure is applied it reduces the volume of the material but then returns to its original state when the pressure is removed. Bulk modulus measures the ability of a substance to withstand changes in volume when under pressure.

References needed throughout

You could have provided some relationships between the various elastic constants here.

You also could have considered the practical significance of each term.

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Expected values

Aluminium beam

Properties		
Modulus of Elasticity	68.9 GPa	10000 ksi
Notched Tensile Strength	138 MPa	20000 psi
Ultimate Bearing Strength	200 MPa	29000 psi
Bearing Yield Strength	159 MPa	23100 psi
Poissons Ratio	0.33	0.33
Fatigue Strength	48.3 MPa	7000 psi
Machinability	30 %	30 %
Shear Modulus	26.0 GPa	3770 ksi
Shear Strength	75.8 MPa	11000 psi
Electrical Properties		
Electrical	0.00000300 ohm-cm	0.00000300 ohm-cm

Using matweb we can see that the expected modulus of elasticity should be 68.9GN/m²

70/30 brass

Properties		
Hardness, Rockwell B	60	60
Tensile Strength, Ultimate	380 MPa	55100 psi
Tensile Strength, Yield	275 MPa	39900 psi
Elongation at Break	48 %	48 %
Modulus of Elasticity	110 GPa	16000 ksi
Poissons Ratio	0.375	0.375
Machinability	30 %	30 %
Shear Modulus	40.0 GPa	5800 ksi
Shear Strength	260 MPa	37700 psi
Electrical Properties		

The expected value of the 70/30 brass rod should be 40.GN/m²

0.4% carbon steel

Mechanical Properties	Metric	English	Comments
Hardness, Brinell	111	111	
Hardness, Knoop	129	129	
Hardness, Rockwell B	64	64	Converted from Brinell
Hardness, Vickers	115	115	Converted from Brinell
Tensile Strength, Ultimate	385 MPa	55800 psi	
Tensile Strength, Yield	325 MPa	47100 psi	
Elongation at Break	18 %	18 %	In 50 mm
Reduction of Area	40 %	40 %	
Modulus of Elasticity	205 GPa	29700 ksi	Typical for steel
Bulk Modulus	160 GPa	23200 ksi	Typical for steel
Poissons Ratio	0.29	0.29	Typical For Steel
Machinability	60 %	60 %	Based on 100% machinability for AISI 1212 steel.
Shear Modulus	80.0 GPa	11600 ksi	Typical for steel

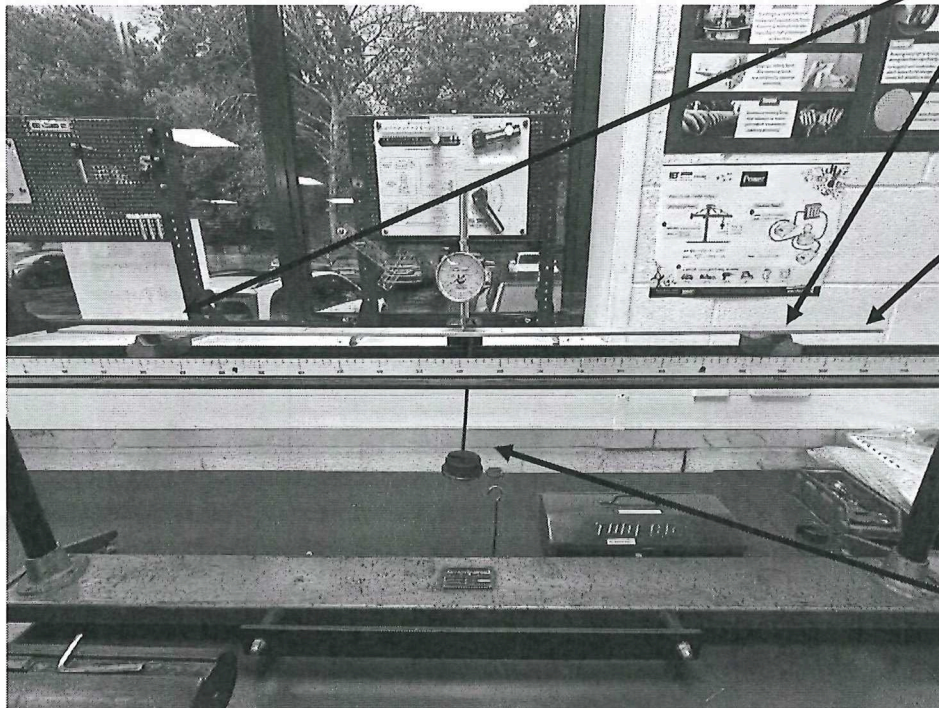
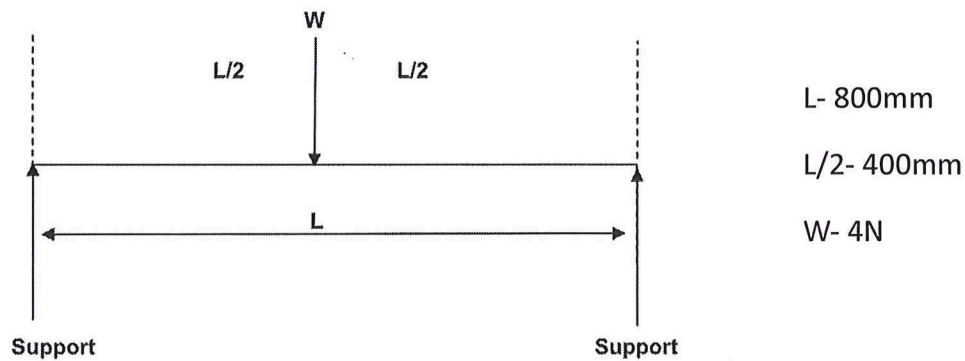
The expected values for the 0.4% carbon steel is 80GN/m²

Results

Effects of loading on a beam

This test was done with an aluminium beam with a length of 800mm, width of 32mm and 5mm thick.

Diagram



Support of the beam

The beam

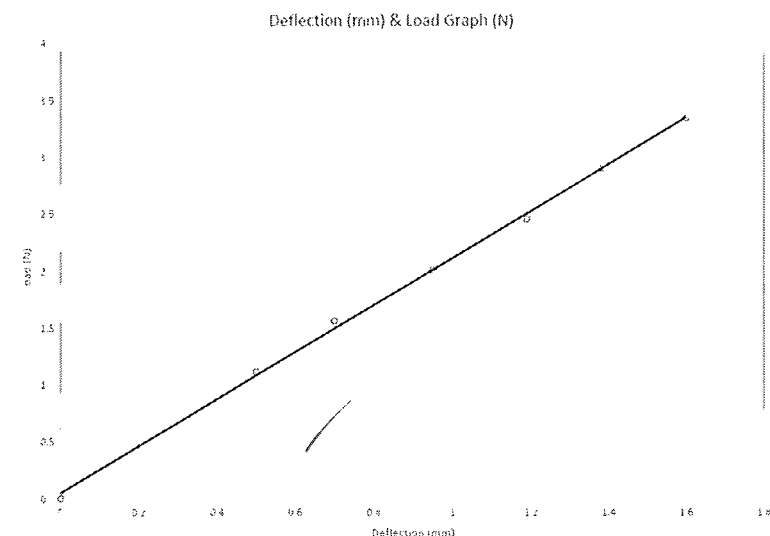
The load given to the beam

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Table

Load (lbs)	Load (kg)	Load (N)	Deflection (mm)
0	0	0	0
0.25	0.1135	1.113435	0.5
0.35	0.1589	1.558809	0.7
0.45	0.2043	2.004183	0.95
0.55	0.2497	2.449557	1.19
0.65	0.2951	2.894931	1.38
0.75	0.3405	3.340305	1.6

Graph



Slope of graph- $y=2.1x$

Calculations

To calculate young's modulus (E) I must first calculate the second moment of area (I):

$$I = \frac{bd^3}{12}$$

b- breadth d- depth of bar

$$\begin{aligned} \frac{32x(5)^3}{12} &= I \\ &= 333mm^4 \end{aligned}$$

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Now that I have the second moment of area, I can calculate young's modulus

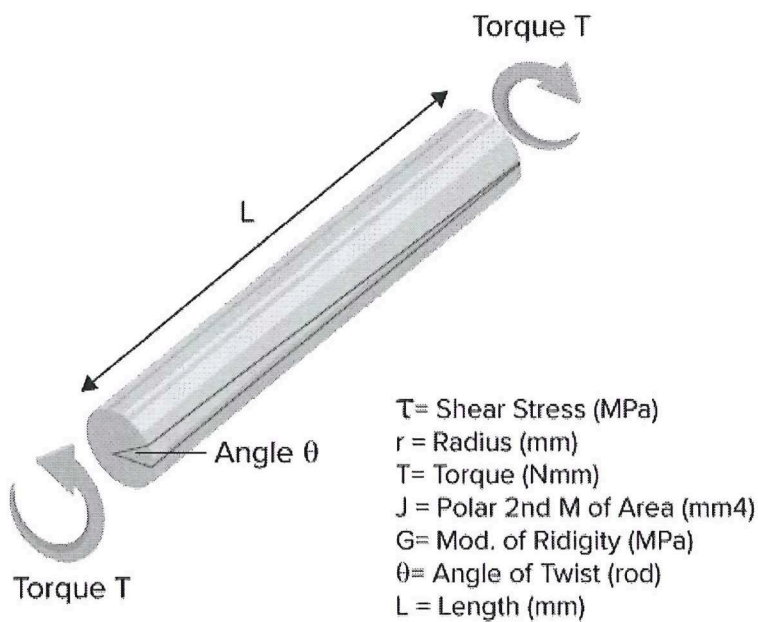
$$E = \frac{L^3}{48I} \times \text{slope of graph}$$

$$\frac{800^3}{48 \times 333} \times 2.1 = 67.2 \text{GN/m}^2$$

Effects of torsion on cylindrical rods

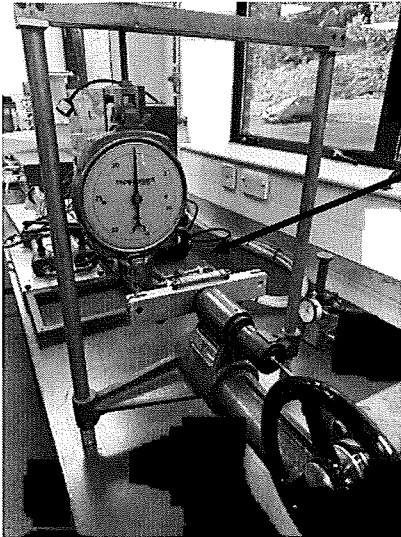
I did two tests of this one was done with a 30/70 brass cylindrical rod and the other was done with a 0.4% carbon steel rod. Both rods were 90mm in length and 5mm in diameter.

Diagram

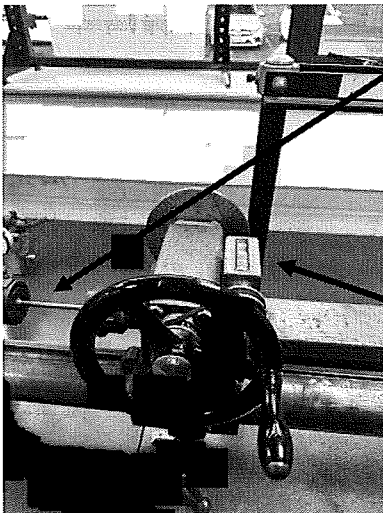


Both rods were done using the same equipment. A torsion wheel rig.

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Torque arm and spring balance which measures the torque applied.



The rod in the rig.

Worm and wheel drive which measures the angle of twist which is given to the rod.

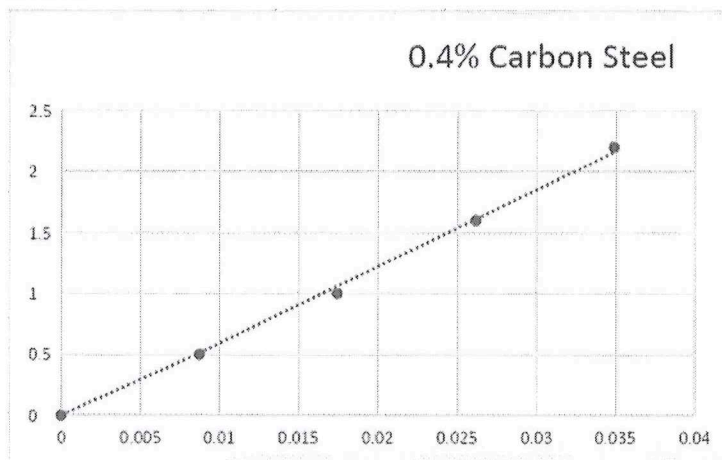
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0.4% carbon steel

Table

Torque Applied (Nm)	Angle of twist (°)	Angle of twist (rad)
0	0	0
0.5	0.5	0.008722222222
1	1	0.017444444444
1.6	1.5	0.026166666667
2.2	2	0.034888888889

Graph



Slope of graph: 61.529

Calculations

Before I calculate the modulus of rigidity (G) I must calculate the polar second moment of area (J). The equation for this is seen below.

$$J = \frac{\pi D^4}{32}$$

32- This is a set number D- Diameter

$$J = \frac{\pi \times 5^4}{32}$$

$$= 6.13 \times 10^{-11} \text{ m}^4$$

To calculate modulus of rigidity:

$$G = \frac{L}{J} \times \text{slope of graph}$$

L- Length of rod

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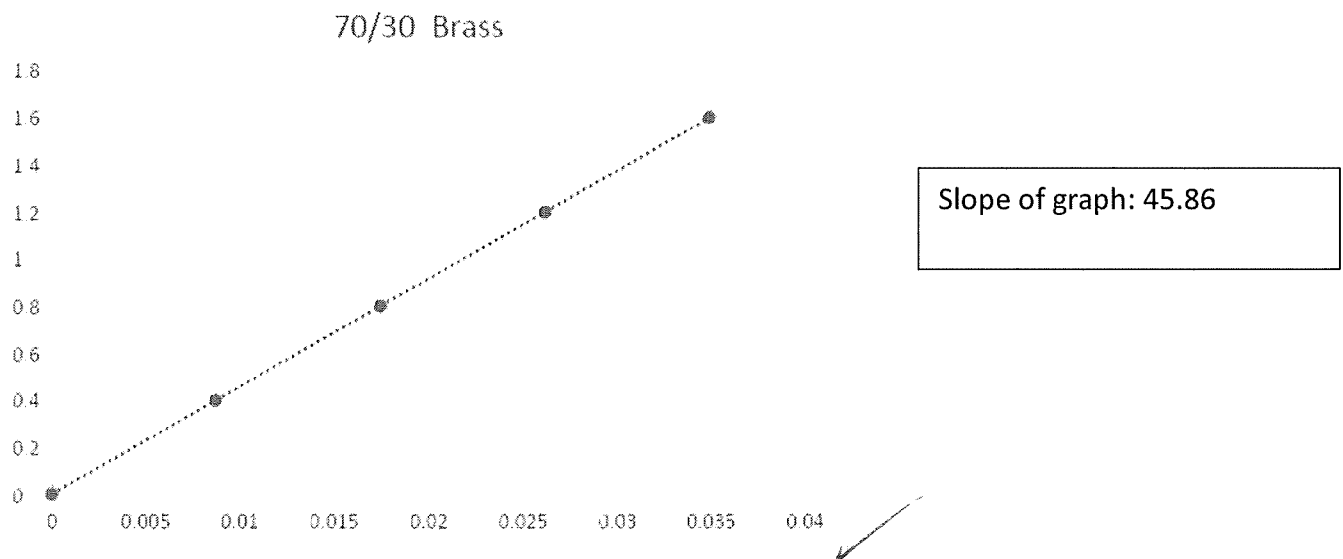
$$G = \frac{0.09}{6.13 \times 10^{-11}} \times 61.529 = 90.34 \text{ GN/m}^2$$

30/70 Brass

Table

Torque Applied (Nm)	Angle of twist (°)	Angle of twist (rad)
0	0	0
0.4	0.5	0.008722222222
0.8	1	0.01744444444
1.2	1.5	0.02616666667
1.6	2	0.03488888889

Graph



Calculations

Before I calculate the modulus of rigidity (G) I must calculate the polar second moment of area (J). The equation for this is seen below.

$$J = \frac{\pi D^4}{32}$$

32- This is a set number D- Diameter

$$J = \frac{\pi \times 5^4}{32}$$
$$= 6.13 \times 10^{-11} \text{m}^4$$

Calculate modulus rigidity:

$$G = \frac{0.09}{6.13 \times 10^{-11}} \times 45.86 = 67.33 \text{GN/m}^2$$

Discussion of results

With the theoretical results and the calculated results there is a significant difference between some. With the aluminium beam the theoretical result was 68.9GN/m² and the calculated result was 67.2GN/m² (A 1.7GN/m² difference) This tells me that there was either an error from rounding up the calculations or that the rig we used wasn't calibrated. The aluminium beam that was used could've been completely different to the theoretical one as I was unsure what aluminium beam, I was using. When applying the load to the beam, the weights that I used could've been off and not 100% correct, meaning the values that I used to calculate the modulus of elasticity was incorrect. The big difference between values is when it comes to the modulus of rigidity of the 70/30 brass rod and the 0.4% carbon steel rod. The theoretical value of the brass rod was 40GN/m² and the calculated value was 67.33GN/m² (A 27.33GN/m² difference), and for the 0.4% carbon steel rod I got a theoretical value of 80GN/m² and a calculated value of 90.34GN/m² (A 10.34GN/m² difference). Again, the rig we used for this test was not calibrated, this means that the results I had are not the true values that I should've been getting. I would also say that due to slippage in the chuck the values could've been off as the rods are not getting the maximum of torque applied. As there is a big difference between the brass theoretical value and the calculated value, I believe that the incorrect brass rod was used.

Conclusion

I believe that overall, the tests went positive, the task that was given was completed and the modulus of elasticity and modulus of rigidity was calculated the materials. I have been able

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to calculate the modulus of elasticity of an aluminium beam and see what kind of stress a beam comes under when different loads have been applied. I have also calculated the modulus of rigidity of two different kinds of materials. I have found out that the modulus of rigidity is different in different materials, where a carbon steel rod has a 23.01 GN/m^2 higher modulus of rigidity than a brass rod does. If I were to do to this experiment again, I would make sure that the rigs I was using have been calibrated, to make sure that there is no slippage in the chuck I would also make sure that I know to certain of the kind of materials I am using.

I would have liked to have seen more on the practical application of theory here.