Rayan sec01 draft 1

MECH3315 Mechanics Laboratory
Sample Lab Report Grade Breakdown

12-Feb-15

S. Daniels

Laboratory Report Guidelines		
Letter of Transmittal	~~5~~	0
Cover Page	~~3~~	1
Abstract	~~10~~	5
Table of Contents	~~2~~	2
Executive Summary (none)	0	
Introduction	~~10~~	7
Literature Review (Project Only)	0	
Methods	10 ~~20~~ 10	9
Results & Discussion	25	0
Conclusions	~~10~~	10
List of References	~~2~~	2
Appendices (excluding Uncertainty)	~~8~~	2
Appendices (Uncertainty Analysis)	~~5~~	
Total Points	100	38

15

23

submit by email by next Thrs.

submit by Thrs - pts.

38

Torsion test

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Executive Summary Abstract before TOC

Torsion testing among the basic mechanical tests which are done to find out the material properties such as shear modulus, the elastic modulus, and shear strength. In the practical lab the "Tinius Olsen Lo-Torq Bench Model Torsion Testing Machine" was used to carry out the test. The material used in the test was Steel specimen. The setup of the lab considered the details given, ensuring the specimen was held tight into the grip. If the specimen is not hold properly the experiment is considered erroneous.

The purpose of the experiment was to observe how different specimen which were used react under torsion force; to determine the torsion of ductile steel; to gain familiarity with torsion testing equipment and testing procedure; and study the fracture surface properties and record the observations. The experiment was conducted to determine the shear proportional limit. At this point, the graphs of shear stress vs shear strain begins to be nonlinear. Second, the experiment tested the Yield shear stress and this value is gotten in the same way tensile yield strength is calculated. Third, the practical aimed at finding the probable Tensile Strength. Four, the practical data was used to calculate the maximum shear strain to due to failure, the maximum elastic shear strain and type and properties of fracture.

a / of a / from Pacific Rim Metals. / Two samples were tested to failure. / determine properties of the two / under

The properties for sh

The shear modulus for the two samples were ... as compared to — from the published. Also, the yield shear stress was — and — as compared to estimated values of — to — ?

what kind of steel...

Conclusion ... how do they compare? one sentence... brief...

Introduction

Torsion testing is used to evaluate the shear modulus, the elastic modulus, strength, and different properties of the steel rod. The "*Tinius Olsen Lo-Torq Torsion Testing Machine*" is a bench type of equipment which is used to carry out torsion tests on test bars by holding them between measurement and force application chucks. The universal machine can apply torsional load weighing up to 1000 Newton's-meters on test specimen ranging between 7.94mm to 38mm in diameter. However, the span between measuring and twisting chuck is adjustable 51cm and the torsional force can be indicated and applied in the two direction of twisting (Patil & Gore, 2017). The loading chuck of the "*Tinius Olsen Lo-Torq Torsion Testing Machine*" is propelled by combination of variable speed D.C motor and gear reduction unit using solid state adjusting circuitry. The normal speed of the machine range between 5 and 360 degrees per min and the angle of rotation is recorded from gauge attached to torque chuck, or it is displayed on model 290 monitor. For convenience in this practical, the system send angle and load through serial port to attached computer.

The working principle of the machine is complex, however, the following steps elaborate the operations. First, the torque loaded on the tested steel is recorded by the Strain Gauge Torsional Load Cell which is attached at the weighing clamp. The detected torque is the converted to electrical signal using resistance strain gage linked with load cell. The test machine which have the Model 290 display has four load ranges of 500.0, 1000.0, 5000.0 & 10,000.0 inch pound-force. These units when converted to metric are: 50.0, 100.0, 500.0 & 1000.0 Newton meters in metric value.

There are different reasons for conducting this type of experiment, the most important one is to check the response of metal such as steel when used, to applied torsion and to check the accuracy of the "*Tinius Olsen Lo-Torq Torsion Testing Machine*" in calculate the applied torque (Wu & Wang, 2010). Moreover, the students who conducted the experiment got skills on torsion testing, the test apparatus used, and the data which gotten from experiment.

At the start of the lab test, a straight line was drawn on the test steel. This enabled the students to tell if the data collected was correct set. If the data set collected was good, then the drawn line on the steel would be wrap around the specimen in an even spaced cycle. The more irregular the spacing, the more unreliable the experiment is.

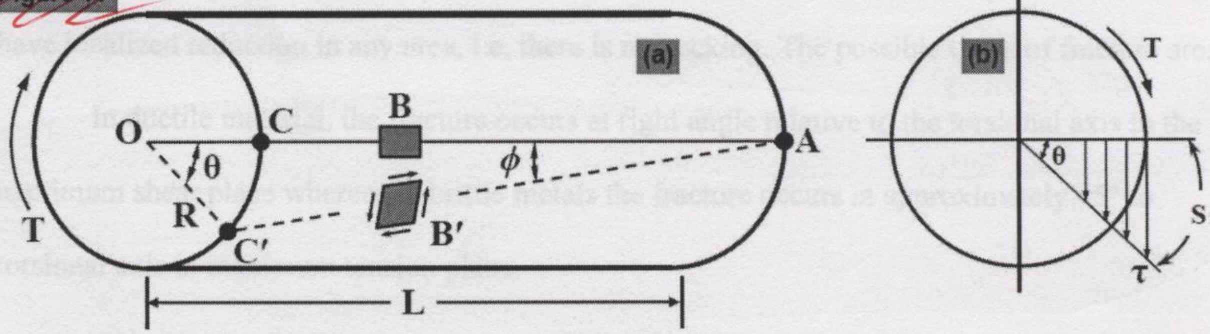
Theory

There are different components and products which are subjected to torsional forces during their operations. Some of these products are fasteners, switches and automotive steering columns. These components are subjected to torsional stresses. By conducting the torsion test, manufacturer assume the working situation, validate the design work, prove the manufacturing quality, and ensure correct manufacturing process and methods. The torsion test is performed by using twisting moment to one side of the test bar while calculating the angular deformation at the other end of the bar.

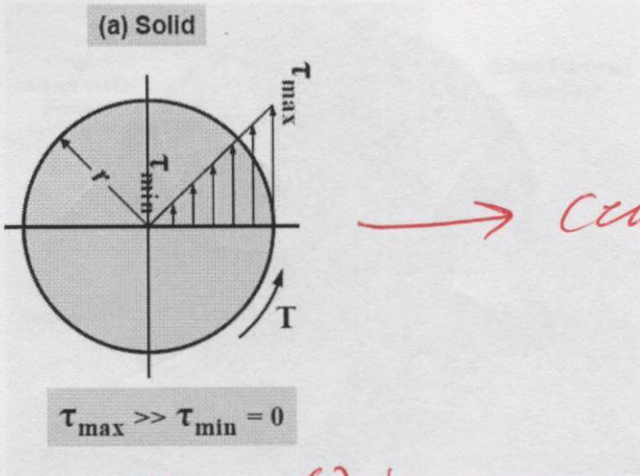
Torsion test is important in defining the steel physical properties such as "shear modulus of elasticity, torsional yield strength, and the shear modulus of rupture." These test can be done using full-size engineering parts to determine the behaviors of material under loading conditions. There are various advantage of torsion test compared to tensile test. Torsion test does not have necking effects and, therefore, the torque increases up to moment of failure. In torsion test, the plastic deformation is uniform over the whole span of the specimen and this concept is used in determining the deformations and stresses for highly ductile materials (Seaburg & Carter, 2009). Some brittle materials which cannot be tested under tensions can be examined using the torsion test which enable the observer to determine the mechanical properties of the brittle material. Moreover, torsion tests can also be done at high strain rates.

During the torsion test, the angle of twist and the torque are measured and using the data from the display, the "torque-twist diagram" is constructed. Further, using the torque-twist diagram, the shear strains and the shear stresses can be calculated by use of the following equations. The experiment used cylindrical steel bar. When the bar is fixed at one and subjected to torsional moment (Torque, T) at the other side, the twist will be through the angle (ϑ). The torsional deformation induce shear stress denoted by (τ) and corresponding shear strain (γ) at the circumference.

Figure 11



Torsion test is however not used in material specification like tension test because it does not generate uniform shear stress. The magnitude of shear stress varies from zero and increase to maximum at the surface of the torsion bar. When the surface of the bar is at elastic limit, the interior part is at elastic range.

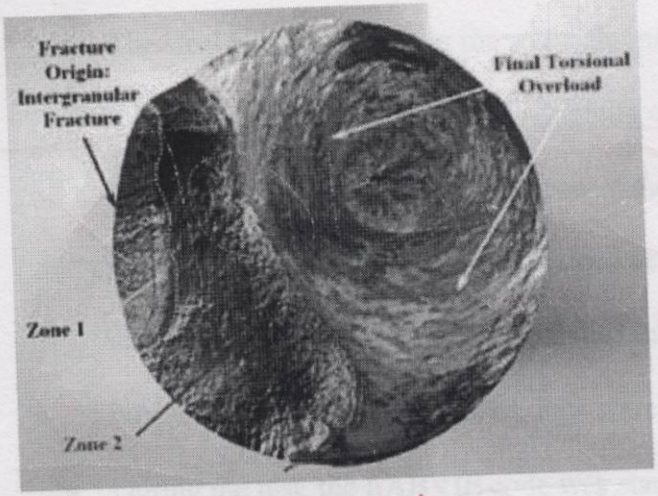


Some of the parameter considered include the modulus of rigidity or the shear modulus denoted by G, this is the stiffness in torsion. The torsional fracture is also different from other types of fracture such as the compression and tension fracture. The torsional fracture does not have localized reduction in any area, i.e. there is no necking. The possible types of fracture are:

In ductile material, the fracture occurs at right angle relative to the torsional axis in the maximum shear place whereas in brittle metals the fracture occurs at approximately 45° to torsional axis in maximum tension plane.

Ductile material

Brittle material



Procedure

- The first process in this lab practical was to measure the diameter of the test specimen using the measuring caliper and rule. These values were recorded for later calculations. After this, a straight line was drawn on the test specimen so that the angel of twist can be check during the experiment.
- The screen was turn on and the program for torsion test (LabVIEW) located on desktop was started. This program display and record data
- Use the SELECTOTWIST Controls to set the chuck to 0° to read the degree of twist from the scale located on the loading chuck. Also, rotate the rotation rate dial to small values.
- Mark the steel bar using permanent color about 25.4mm from the two ends and measure the length of the steel bar to be twisted. Repeat the measurement of the length to find accurate value.
- The display was set up to the right measurement units for proper units and maximum torque reading and 200^0 rotation was selected

1. τ_{prop}	X	O	X	O	X

estimated

	Rb	S_1	ε_{diff}	S_2	ε_{diff}
2. τ_{ys}	O	O	O		O
3. σ_{TS}	O	$\frac{\tau_{max}}{0.55}$	O	$\frac{\tau_{max}}{0.55}$	✓
4. ϕ	✓	✓	✓	✓	✓

0.55 (σ_{ys})

Material

Material value.

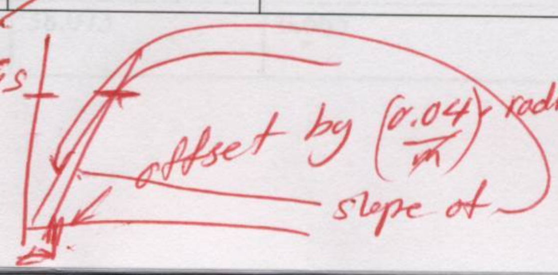
5. γ_{max} elastic	X		X		X
6. γ_{max} failure	X		X		X
7. Brittle or ductile	X	O	X	O	Flat – ductile Angle – brittle

- The steel bar was mount in the self-tightening grip holders of the torsion tester. The loading was done by sliding the weighing chuck of the machine bed and opening the grips of the holders to allow insertion of the steel bar. When using the bolt mechanism, the clamp of the weighing chuck should be tightened sufficiently to avoid the weighing chuck from lifting. The tightness of the chuck grip should be sufficiently loose for horizontal movement. The lathe dogs were tightened to prevent slipping.
- During the test, the LABVIE code was started and the speed of rotation set. The direction of twist was selected from the SELECTOTWIST guide. The speed of rotation can be adjusted during the experiment if need be. For better result, it is advisable to select the speed of rotation which allows the torque to be read easily and produce many data points in the 0^0-30^0 range. As the test profess, the specimen exceed the elastic limit and the torque value is level off.
- After the failure the broken halves should be removed. Also, the specimen should be examined of failures such as fracture surface and the observation recorded.

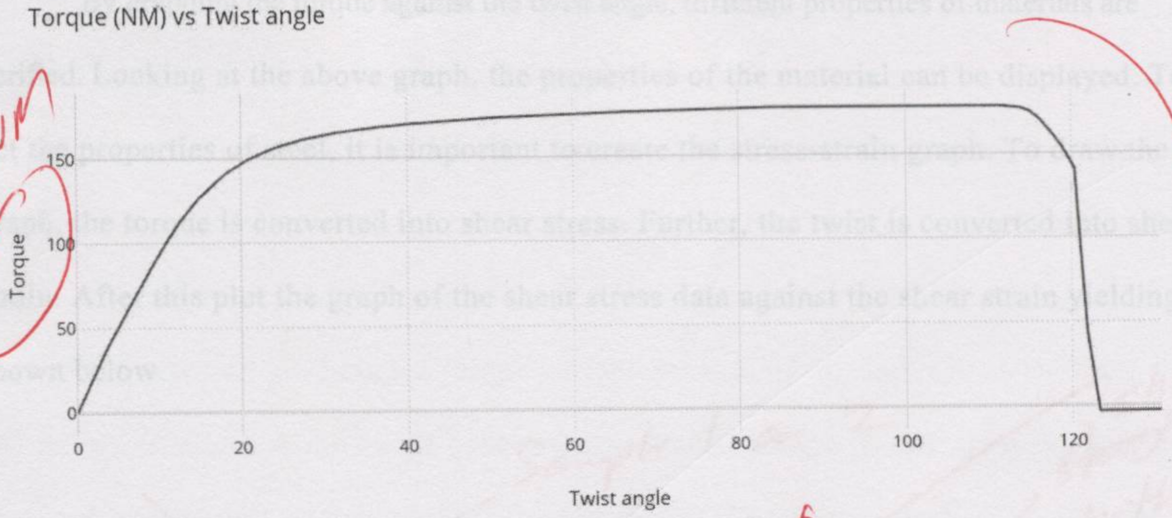
Results

The experiment on the steel bar in the torsion machine produced two set of valuable data. The first set of data give the qualitative observation. From the qualitative observation the behavior of the steel rod can be assessed. The second set of data give the torque and twist angle of on the specimen, providing the data for graphical representation and shows the behaviors of the test of materials.

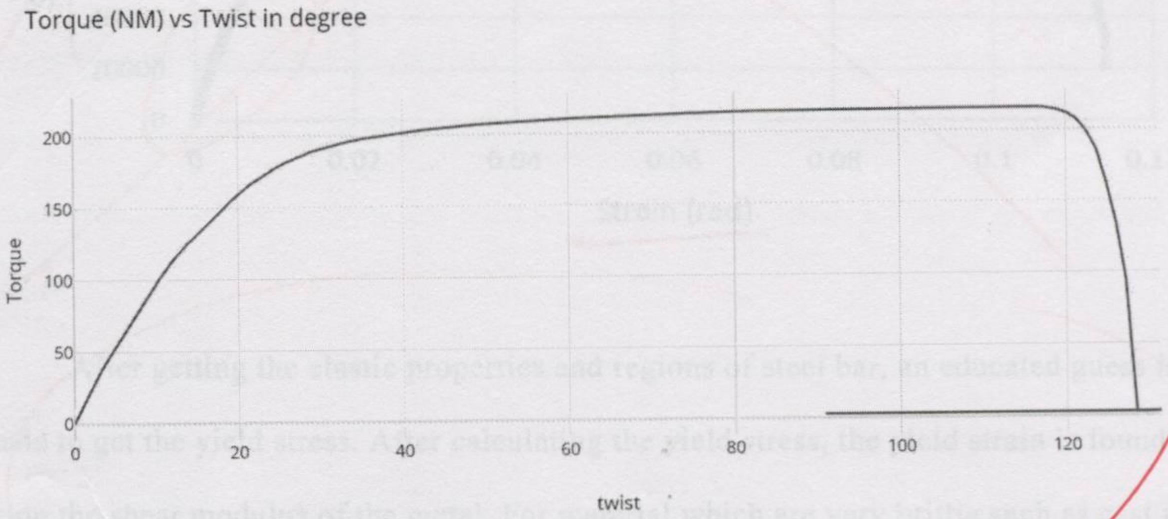
Load (NM)	Twist in degrees	Twist in rads
0.003	0	0



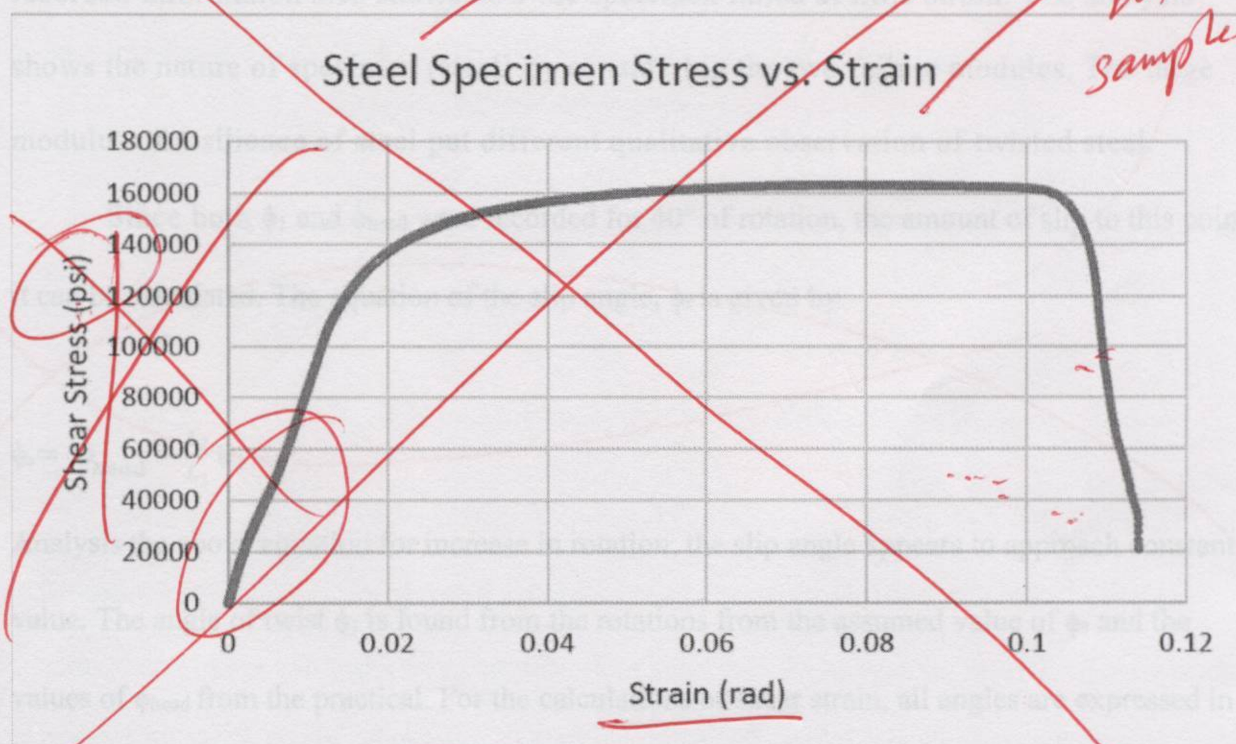
11.325	1.017	0.018
20.495	1.782	0.031
31.347	2.727	0.048
41.124	3.716	0.065
51.655	4.875	0.085
60.449	5.866	0.102
70.635	6.957	0.121
80.422	8.099	0.141
90.355	9.186	0.16
101.201	10.487	0.183
111.091	11.742	0.205
120.971	13.214	0.231
130.554	14.787	0.258
140.455	16.632	0.29
150.897	18.406	0.321
160.034	20.16	0.352
170.678	22.551	0.394
180.049	25.308	0.442
190.363	29.738	0.519
190.979	30.079	0.525
195.203	32.997	0.576
200.02	37.569	0.656
200.392	38.073	0.665


Torque (NM) vs Twist angle
Torque
0
50
100
150
0
20
40
60
80
100
120
Twist angle

Data set 2


Torque (NM) vs Twist in degree
Torque
0
50
100
150
200
0
20
40
60
80
100
120
twist

By graphing the torque against the twist angle, different properties of materials are verified. Looking at the above graph, the properties of the material can be displayed. To get the properties of steel, it is important to create the stress-strain graph. To draw the graph, the torque is converted into shear stress. Further, the twist is converted into shear strain. After this plot the graph of the shear stress data against the shear strain yielding as shown below



After getting the elastic properties and regions of steel bar, an educated guess is made to get the yield stress. After calculating the yield stress, the yield strain is found using the shear modulus of the metal. For material which are very brittle such as cast iron are not resilient and, therefore, they have no modulus. The diagram of shear stress against shear strain acting on the steel is used to determine the modulus of toughness.

Analysis DISCUSSION

The analysis of the above results requires several assumption in order to make conclusions. The assumption which was confirmed was the ductile property of mild steel. The ductility of steel can be confirmed based on the failure surfaces of the sample. The right angle failure of specimen shows that the mild steel failed because of shear. Material such as the cast iron have angled failure surface because of maximum-tensile-stress. The flat failure as shown in the above experiment is typical failure for ductile material. The recorded information also shows how the specimen failed at little strain. The analysis shows the nature of specimen (steel) by considering the two failure modules. The large modulus of resilience of steel put different qualitative observation of twisted steel.

Since both ϕ_1 and ϕ_{head} were recorded for 40° of rotation, the amount of slip to this point it can be calculated. The equation of the slip angle, ϕ_s is given by

$$\phi_s = \phi_{head} - \frac{L_2}{L_1}\phi_1$$

Analysis the above equation for increase in rotation, the slip angle appears to approach constant value. The angle of twist ϕ_1 is found from the rotations from the assumed value of ϕ_s and the values of ϕ_{head} from the practical. For the calculations of shear strain, all angles are expressed in radians.

Shear modulus or the "*modulus of rigidity*" is symbolized by G and it is the ratio of shear stress to shear strain. (Wu & Wang, 2010). In case of fixed end like in this experiment, the Nadai method is used to convert the torque and twist angle values to shear stress and shear strain values respectively. The Nadai method is used since there is no axial length change. Torque-twist graphs values are changed shear stress vs. shear strain graph.

Shear modulus G can be determined from the following equation:

$$G = \frac{2t}{\pi R^4}\left(\frac{T}{\theta}\right)$$

The value of shear strength can only be determined experimentally. Under the static loading of the specimen, the stress element is considered as the shear strength is calculated based on different theories. From the steel which is ductile, the strength can be calculated using:

- *Maximum Shear Stress.* In this case, shear strength is calculated as:

$$Shear\ Strength = \frac{1}{2} \times yield\ Strength.$$

- *Distortion Energy Theory.* The shear strength is given by:

$$Shear\ Strength = 0.577 \times yield\ Strength$$

From the graph, some information about the material can be defined. Some of the information include the shear yield strength, the proportional limit, the shear ultimate strength, and shear modulus of elasticity. The steel has yielding torque of 145Nm which is caused by yield stress of about 712,938,577N/m^2. To get shear stress the following equation are used:

Shear stress= $\frac{TC}{J} = \frac{TC}{\frac{\pi C^4}{2}} = \frac{2T}{\pi C^3}$

The shear yield strength $= \frac{2\times640}{\pi\times0.248^3} = 53{,}423.9\,\frac{lb}{in^2} = 368.3448$MPa

Where:

T=torque

C =radius

J =polar moment of inertia for the cylindrical bar.

The ultimate strength is calculated as

Ultimate strength= $\frac{2T}{\pi c^3}$= $\frac{2\times1953}{\pi\times0.2487}$=161564.4$lb/in^2$= 1113.9473MPa

Errors (factors which affect the results)

Though the results of the confirmation expected values from the lab test, in finding the derived mechanical properties of the steel bar to the known properties of test steel bar there are some discrepancies. The shear modulus (67.4Gpa) does not match with the theoretical value (79.3GPa), the error can be as a result of using the wrong domain for elastic region of the material. The main source of the error reported could be because of incorrect units and not knowing the SI units for the different modules. To prevent the errors is easy, by simply familiarizing with the terms and machine operation before experiment. Despite the large amount practical errors, the experiment was informative. The torsion testing provide the characteristics of material just like the tensile test. Knowing the properties of steel helps in understanding how the material is used. Steel is suitable for moving bodies because of its resilient properties. It can be used in build structures especially in areas prone to earthquake. Understanding the mechanical properties gives insist to design process.

Another source of error in the above experiment could be the tightening of the specimen in the grips. If the grip is too tight, the material develop scratches and fail at that region. If the specimen is not tightened and the grip is loose, then it slip and data collected become unreliable (Hibbeler, 2011). The solution to the gripping problem is to use a gage which specify the grip strength. Other possible sources of error are: bend specimen could have been used and the angle of twist could have developed at rapid pace. If angle of twist is added rapidly, then planes of the structure would have insufficient time to slide past each other and the specimen would fracture sooner compared to case scenario where the angle of twist is applied at slower rate.

New page

Conclusion

The torsion test was performed on the steel specimen~~s~~ provided by Pacific Rim Metals. ~~One end was fixed in the grips and the other end of the steel bar was attacked to the "*Tinius Olsen Lo-Torq Bench Model Torsion Testing Machine*". Torque was directed to the steel bar by the machine until the yield point was noticed. Once the movement could be seen by the deformation lines formed at the outer surface of the specimen. The steel specimen withstood high torque before fracture. The shear stress vs. shear strain diagram was created for the specimen. From the diagram shear yield strength, shear modulus of elasticity and shear ultimate strength was calculated.~~ The error between true value and experimental value was large. The sources of error in the practical include steel slipping out of grip.

specific

Conjecture

Given how different the data is, it is possible that the grips may have slipped. Further testing is needed.

Replace with a comparison of results from the two sample vs. published data, Talk about the differences, use % not opinion

These sample do not match published very well and may not be (?). Further testing is recommended

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Lab Report Guidelines for 3xxx Courses (Junior Level)

Tagliatela College of Engineering

General Descriptions of Laboratory Report Components

(Components are selected as needed for each assignment.)

Lab Report Component	Component Description
Letter of Transmittal, or Memo of Transmittal a.k.a. memo (Accompanies the report, one page, not technical)	❖ A transmittal letter (for external audiences) or memo (for internal audiences. These brief formal letters follow an employee (or lab instructor) assigned standard format. Limit to 1 page- as small as 1 paragraph, includes any anomalies that occurred.)
Cover Page	❖ A single page that normally includes title, author (s) name, names of colleagues, the course name, and the date the work was done and the date the report was written. ❖ The format and content are specified by those requesting the report. ❖ A graphic may be used to show company/university affiliation or to show major lab setups.
Abstract (formal, documents work for archiving)	❖ Consists of no more than 150-250 words. ❖ States the *major* objectives. Not in physics where research can be very open ended and not goal driven. ❖ Briefly describes the methods and materials employed, especially if they are novel or unfamiliar. For established methods, a name for the technique or key equipment is given. ❖ Summarizes *important* results and conclusions.
Table of Contents	❖ A list of section titles used in the report, with page numbers to the right.
Executive Summary (strategic document, ~5% of total length of report, at the beginning of report)	❖ Similar to an abstract but targeted to those who may be making decisions based on the content of the report. Larger audience, external sponsor. ❖ Clear and concise statement of results and conclusions. Length varies.
Introduction	❖ Lists objectives of the study in order of importance. (Not for more open ended scientific research. The psychological intent of the researcher is seldom mentioned.) ❖ Provides background on the experiment, including relevant theory on which the experiment is based. ❖ Theory may be included, equations are numbered. ❖ Citations & discussion of important previous studies.
Literature Review	❖ For thesis work where the uniqueness of the research must be established or to provide a broad context for the work. Citing relevant work can allow the report to be searched for through a citation index.

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Lab Report Component	Component Description
Methods and Materials (apparatus, equipment, software) Provides only enough detail to replicate the experiment.	❖ Methods Identifies by name commonly accepted methods. Lists in order, the procedures performed. ❖ Materials Provides a description of apparatus and its components if readers would not be familiar with it. Often includes a sketch or photograph of the apparatus. Identifies the materials employed and their relevant properties. (In table format)
Data and Results Presents data and results pertinent to the primary objective or argument from experiments, simulations, models.	❖ Pertinent data are presented in formats (graphs, tables, diagrams, etc.) that reveal critical relationships (trends, correlations, etc.) ❖ "Raw" (directly measured) data can be presented if they are not too detailed to disrupt the flow of reading.
Discussion	❖ Interpret the data & results in light of what you expected, and/or make comparisons to published information. ❖ Identifies and explains any unusual or surprising results. ❖ Identifies the significant sources of error and assesses the reliability of your results.
Conclusions/Recommendations	❖ Restates significant limitations, assumptions or violations of assumptions that qualify the conclusions. ❖ Based upon results and discussion, list conclusions in **order of importance**. ❖ Assess the extent to which each objective has been met. ❖ Provides any recommendations that derive from the conclusions.
Works Cited	❖ Uses appropriate format (Council of Science Editors, IEEE ...) to list sources. ❖ Includes sources used in designing the experiment, writing the lab report, discussing theory or for citing standard equations.
Appendices	❖ Provides detailed information (raw data, calculations, etc.) that are too cumbersome to include in the body of the report. These data might interest only a few readers, especially those who verify the validity of results.