OBJECTIVE

To understand and determine the elastic, plastic and yielding behaviors of different materials when subjected to twisting moment or torsional load.

LEARNING OUTCOMES

At the end of this laboratory session, students should be able to:

1. Conduct experiment and identify the dependent and independent variables.
2. Plot the graph of twisting angle versus torque.
3. Determine the important parameters such as shear yield strength, elastic region, plastic region, maximum shear load/torque and understand the importance of such parameters in design of structure subjected to twisting moment or torque.
4. Determine the modulus of rigidity (G) for the tested materials and make comparison between experimental and theoretical results.
5. Understand and observe the fracture behavior of tested materials due to twisting moment/torque.
6. Understanding of basic laboratory practice, including design of experiment, write a clear and well-presented technical report, data acquisition, interpretation and analysis and the relationship between experimental and theory.

THEORETICAL BACKGROUND

Torsion refers to the twisting of a shaft loaded by a torque, or twisting couples. For example, in the generation of electricity shafts carry torque from the turbine to the generator. An example of torsional loading is shown in Figure 1. In this example the shaft is loaded by two equal and opposite forces acting on a bar perpendicular to the shaft. The moment generated by these forces is sometimes called a couple. The magnitude of the moment due to this couple is given by *P* times *d*, where *P* is the applied forces and d is the distance between the lines of action of the forces. This twisting couple is also called the *'Torque'* or *'Twisting Moment'*. Two alternate ways of depicting torque are shown in Figure 2. In the left-hand figure the torque is shown as a loop with an arrow depicting its direction. In the right hand figure the torque is shown a vector moment.

The derivation and interpretation of the theory of torsion of circular shafts can be review by looking at a small section of length *dx* of a circular shaft under torsion. During twisting, one end of the shaft will rotate about the longitudinal axis with respect to the other end. The magnitude of this rotation is measured in terms of the angle in radians by which one end rotates in relative to the other. This is called *'Angle of Twist'*.

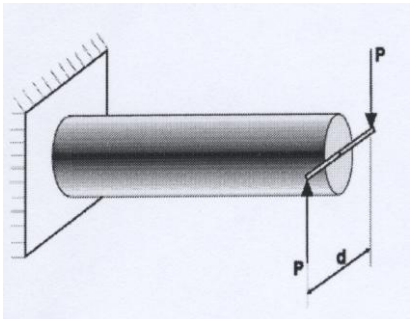

Figure 1 Example of torsion loading

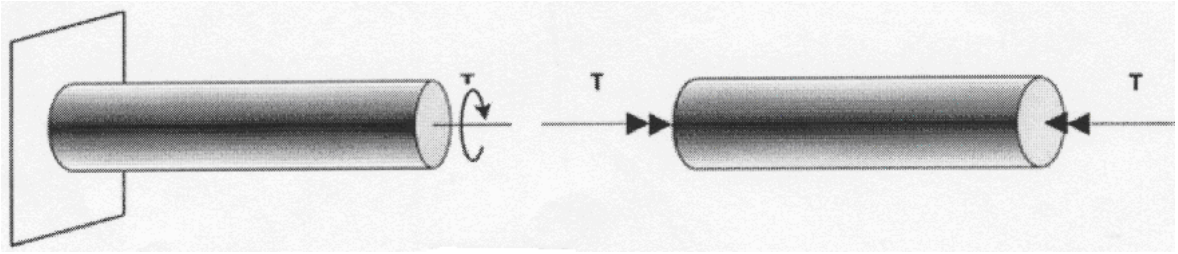

Figure 2 Two alternate ways of depicting torque

For a linear elastic material, using Hooke's Law, we can write the shear stress as:

$$\tau = G\gamma\,, \tag{1}$$

The shear strain on a small area of a material situated at a distance p from the center to be:

$$\gamma = \rho\Phi / L \tag{2}$$

Thus using Hooke's Law, shear stress can be expressed as:

$$\tau = G\rho\Phi / L \tag{3}$$

The torque, *T* is found by integrating over the cross section the product of shear stress, τ and the distance, ρ from the center of the shaft.

$$T = \int \tau\rho dA \tag{4}$$

Using stress from previous relations, we get

$$T = \int G\left(\Phi / L\right)\rho^2 dA = G\left(\Phi / L\right)\int \rho^2 dA = G\left(\Phi / L\right)J \tag{5}$$

Where *J* is the polar moment of inertia

Using the above the relation between the twist and the torque is given by:

$$\Phi = TL / GJ \tag{6}$$

EQUIPMENT & SPECIMEN

1. Torsion test machine model SMXXX complete with torque measurement unit and digital torque meter.
2. Three types of specimen are provided:
   a) Mild steel
   b) Aluminum
   c) Brass
3. Measurement tools

TASK

1. Your experiment must be conducted to investigate and determine relationship between twisting angle and applied torque of the specimens.
2. All necessary data and results must be measured, recorded or tabulated systematically to facilitate its analysis and interpretation at the later stage of your work.
3. Comparison of experimentally determined results with the theoretical data must also be presented, analyzed and discussed in your report.

LAB REPORT

1. Title
2. Objective(s)
3. Introduction and Theory (Detail development and explanation of the underlying concept)
4. Apparatus
5. Procedures
6. Data and results
7. Analysis and discussion
8. Conclusion
9. References (Bibliography)