Lab Manual **Mechanics of Materials-I**

EXPERIMENT NO. 4

Objective:
To determine the Modulus of Rigidity (G) of the given material of circular shaft.

Apparatus:
Torsion of shaft apparatus, Hangers and Weights, Vernier Calipers, Micrometer, Steelrule

Torsion of shaft apparatus includes a shaft of circular section, two measuring scales and a pulley with a frame.

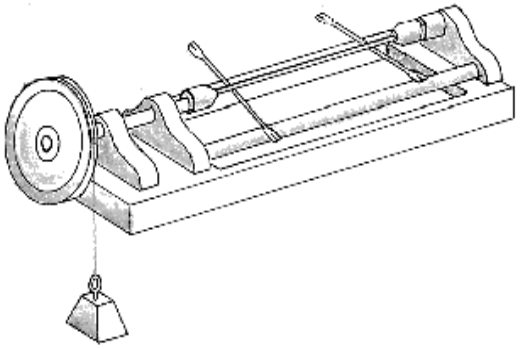

Figure (a): Torsion of shaft apparatus

The main purpose of the pulley with hanger is to apply some load on the circular shaft. Similarly, the scales attached to the frame are used to measure the torsion in the circular shaft. Actually, two scales are used, one at the front and one at the back.

The measuring arm (scale) is used to measure the magnitude of the torsion at the front and the back of the circular shaft respectively. The front is the portion of the shaft that is near to the pulley and the back is the portion of the shaft near the back support of the frame. The main purpose of the frame is to support the shaft and balance the apparatus on the surface.

Summary of Theory:
Torsion is the engineering word used to describe the process of twisting a member about its longitudinal axis.

Consider a solid circular shaft of radius "r" and length "L" fixed at its back face as shown in figure (b). A line AC is marked on the shaft. If a torque "T' is applied at its free end, line AC will acquire the shape of a helix and point A will move to A□.

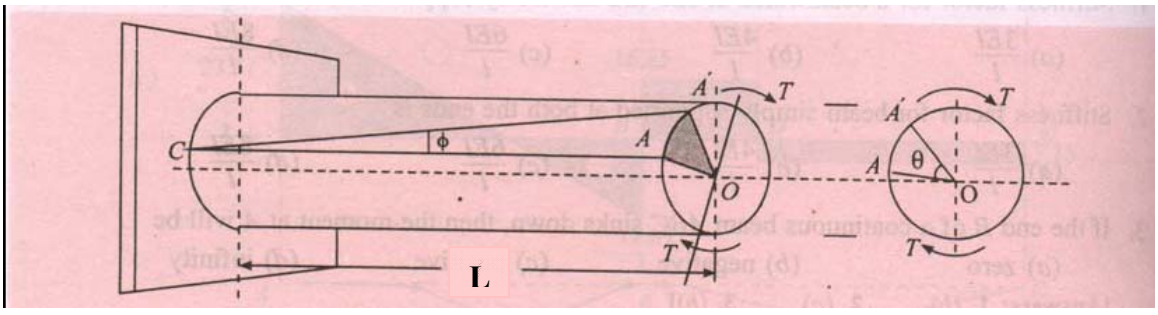

Figure (b): Torsion of shaft

Then from figure,

Angle of twist, $\theta = <AO\ A\square$

Now consider a longitudinal fiber at distance "ρ" from the axis of the shaft.
Deformation in longitudinal fiber, $\delta s = AA\square = \rho\theta$
Strain in longitudinal fiber, $\gamma = \delta s / L = \rho\theta/L$
Stress in longitudinal fiber, $\tau = G\theta$

The shearing strain is maximum on the surface of the shaft where $\rho = r$.

If J is the Polar moment of inertia of the shaft, then using above information the torsional formula for a circular shaft can be written as:

$$\mathbf{T/J = \tau/r = G\theta/L}$$

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or

$$\mathbf{G = TL/ J\theta}$$

The torsional formula describes the relation of applied torque with the angle of twist and stresses produced in the shafts.

Procedure:

1. Place the apparatus on a smooth horizontal surface.
2. Measure the effective length of the shaft using steel rule.
3. Measure the diameter of the shaft using micrometer.
4. Adjust the Zeros of the measuring arm.
5. Put a load of one pound (5N) in the hanger.
6. Measure the angle of twist of the shaft.
7. Take a set of six readings of increasing value of load and then take readings on unloading.
8. Calculate the "Modulus of Rigidity (**G**)" of the material of the shaft.

Observations and Calculations:

Effective length of shaft (L) = _____ m

Diameter of shaft (d) = _____ m

Diameter of torque pulley (D) = _____ m

Radius of torque pulley (R=D/2) = _____ m

Polar Moment of Inertia of the shaft ($J=\pi d^4/32$) = _____ m^4

No. of Obs.	Load W (N)	Torque T = WR (N.m)	Angle of twist at measuring arm θ (rad)			Modulus of Rigidity $G=TL/J\theta$ (Nm^2)
			Loading	Unload.	Average	
1.						
2.						
3.						
4.						
5.						
6.						

Name: _____ **Reg. # _____**

Date:

Report:

The laboratory report should contain the following:

1. Hand calculations showing all results requested in (8) under procedure above.
2. A discussion / comments of factors affecting the results of the experiment.
3. Practical Applications