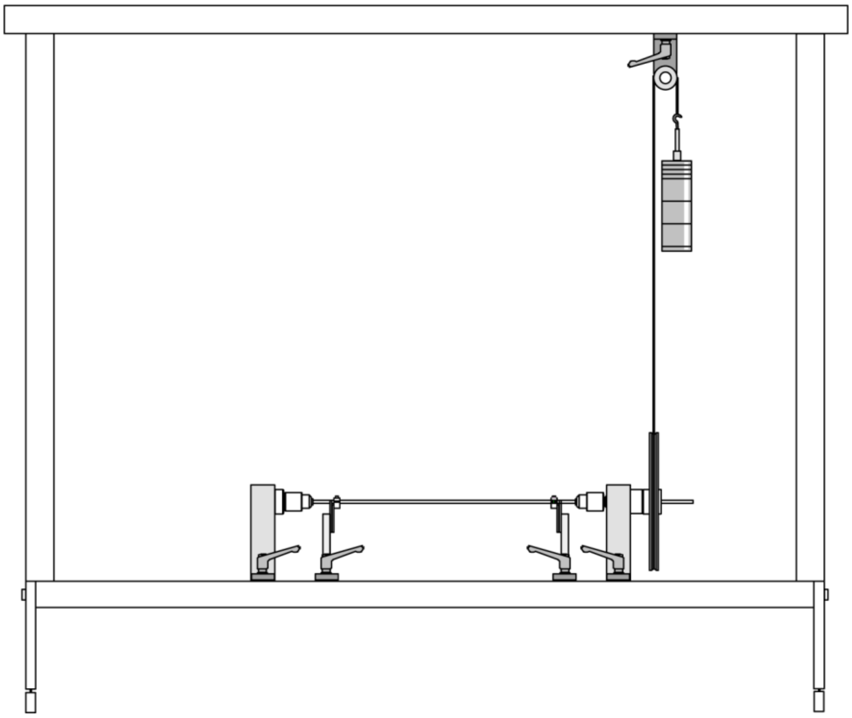
Laboratory 2

Torsion of Bars



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Contents

1. Objectives:

Students are required to study the principles of torsion testing, practice their testing skills and interpreting the experimental results.

Students are able to check the mathematically determined angle of torsion of the bar subjected to torsion loading.

Students are able to measures the angle of torsion of the bar subjected to torsion loading and compares it with the result of the mathematical calculation.

2. Introduction:

The Torsion of Bars device can be used to investigate the fundamentals of torsional loading.

For this purpose, the apparatus is supplied with several brass test bars which are loaded with a moment by means of weights and a pulley. Two adjustable scales permit reading of the torsion angle at any given cross-section.

Two chucks allow quick and easy replacement of the test bars.

3. Equipment description:

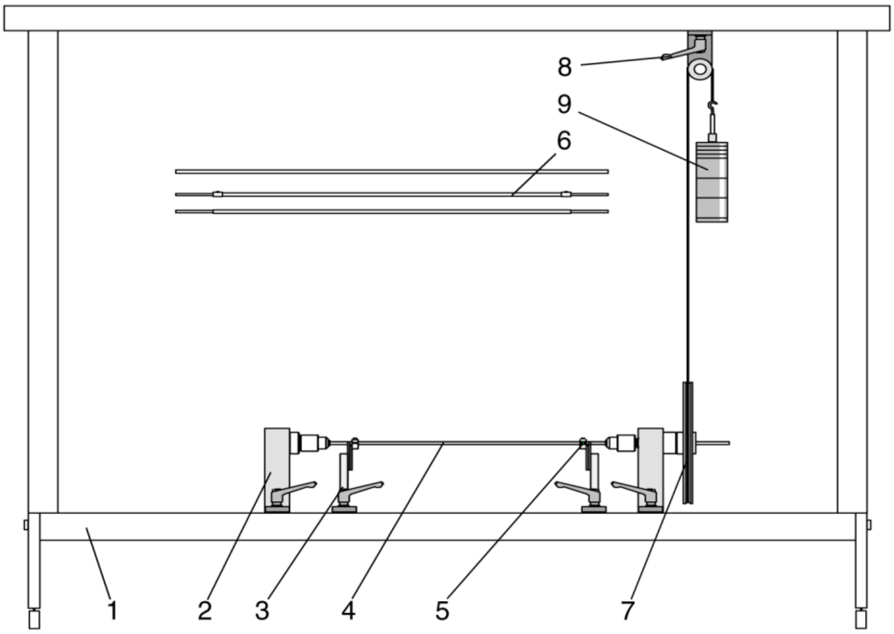


Fig. 2.1 Unit design

1 Universal Test Frame SE 112

2 Chuck, adjustable

3 Adjustable angle scale

4 Chuck-mounted test bar

5 clamped-on pointer for angle scale

6 Additional test bars of differing cross-section

7 Wheel for introducing moment

8 Adjustable guide pulley

9 Hanger with weights

To remove previous test bar:

1. Release both pointers for angle scale (3): Slacken off hexagon socket-head bolts M 2.5 (a).
2. Open left chuck and move it to the left. (b)
3. Release right chuck, take out test bar and remove pointers (c).

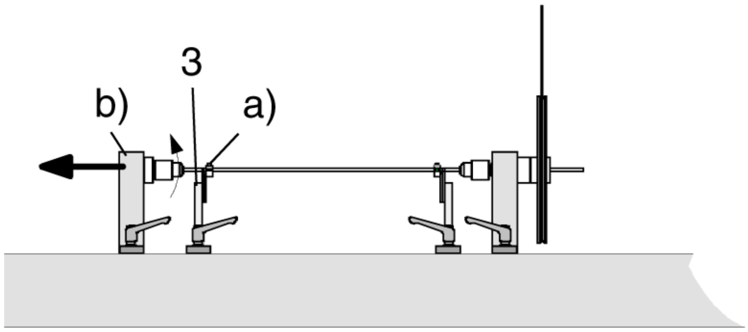


Fig. 2.2 Remove previous test bar

Fitting new test bar

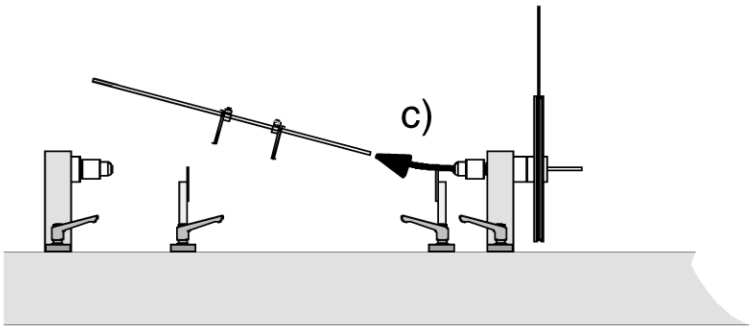


Fig. 2.3 Fitting previous test bar

1. Slip pointers loosely onto desired test bar.
2. Insert test bar with pointers into right chuck, thread pointers between angle scales and insert test bar into left chuck.
3. Firmly close both chucks to prevent test bar slipping through under load.
4. Set desired distance between angle scales.
5. Adjust pointer in front of angle scale and secure in 0° position (Fig. 2.4).
6. Apparatus is now ready for performance of experiment.

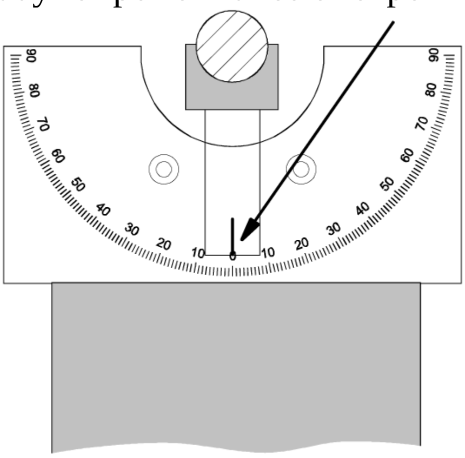


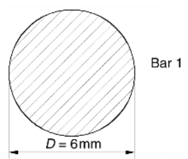
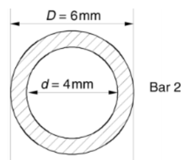
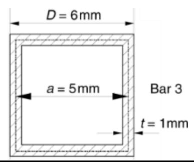
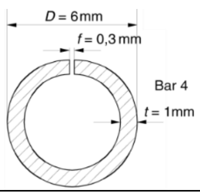
Fig. 2.4 Adjusting pointer in front of angle scale

4. Formula Symbols and Units Used

Symbol	Mathematical/physical quantity	Unit
L	Torsion length	mm
φ, φ_1, φ_2	Torsion angles	°
F	Force, Load	N
M_T	Torsion moment	N.mm
R	Radius of pulley = Lever arm	mm
τ_t	Torsional stress	N/mm²
G	Shear modulus	N/mm²
I_P	Polar moment of inertia of area	mm⁴

5. Coefficients and specimen's characteristics

various cross-sections and there Polar moments of inertia of area

Bar 1		$I_P = \frac{\pi}{32} D^4$	$I_P = 127,23mm^4$
Bar 2		$I_P = \frac{\pi}{32}\left(D^4 - d^4\right)$	$I_P = 102,10mm^4$
Bar 3		$I_P = a^3.t$	$I_P = 125mm^4$
Bar 4		$I_P = \left(\frac{1}{3}.\frac{(D+d)}{2}.\pi - f\right).t^3$	$I_P = 5.14mm^4$

- Shear modulus for brass $G = 40000\ N/mm^2$
- R radius of pulley (lever arm $R = 110mm$)

6. Safety Instructions

	NOTICE The test bars would be ruined by plastic deformation and thus become unusable. The slotted test bar in particular should not be subjected to a load of more than 3 N, the others not more than 20 N.
	NOTICE The angle pointer is very sensitive. Take care when mounting and removing; Take care not to break off pointers.

7. Basic principles

The torsion moment M_T applied is calculated as follows

$$M_T = F.R \qquad \text{Eq. 2.1}$$

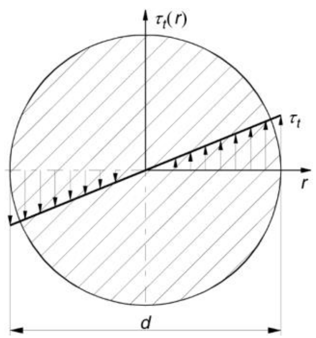


Fig. 2.5 Shear-stress distribution over the bar cross-section

where:

F force applied

R radius of pulley (lever arm $R = 110mm$)

On the basis of this torque, the torsional stress τ_t across the bar cross-section is

$$\tau_t.(\mathrm{r}) = \frac{M_T}{I_P}.r \qquad \text{Eq. 2.2}$$

This represents the shear-stress distribution over the bar cross-section as shown in Fig. 2.5.

I_P is the polar moment of inertia of area, which is governed by the cross-sectional area and the cross-sectional shape of the torsion bar. Tab. 4.1 provides a list of the torsion bars used in the experiment.

The resultant torsion angle is calculated as follows:

$$\phi = \frac{M_T.L}{G.I_P}.\frac{180}{\pi} \qquad \text{Eq. 2.3}$$

Where

L - Torsion length

G - Shear modulus

8. Experimental Procedure

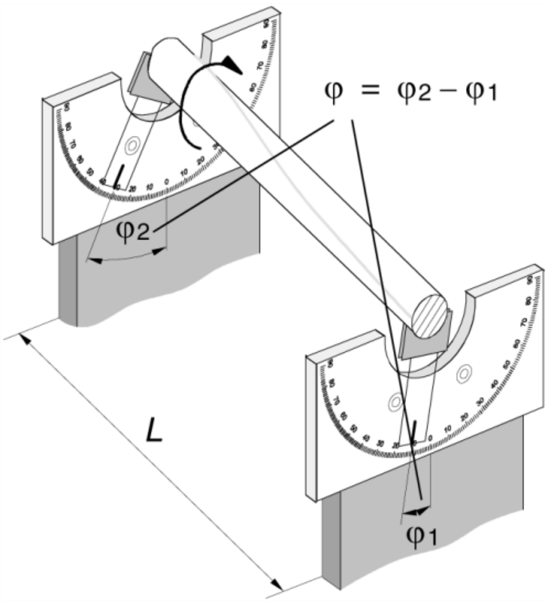


Fig. 2.6 Torsion angles

1. Select test bar and mount it as described in paragraph 3
2. Set torsion length L (e.g. 200 mm) and adjust scale pointers to value of 0°.
3. Attach weights (in 5 N stages, slotted tube in 1 N stages)

4. Record and read off the difference between the two torsion angles (Fig. 2.6)

   $\varphi = \varphi_2 - \varphi_1$

5. Repeat experiment up to a max. load of F = 20 N (max. load for slotted test bar max. 3 N!)
6. The experiment should be performed with various test bars.

9. Questions

-Do the experiment as described in paragraph 7, and measure the torsion angles for all the test bars, then compare the measured values by calculated angles (Eq. 2.3 and table 2.1).

-Discuss the obtained experimental results and give conclusions.

10. Results

1- Mathematical calculation

2- Results

Test bar 1: Round bar Φ 6 mm

Load F $[N]$	Torque M_t $[N.mm]$	φ_1 measured $[°]$	φ_2 measured $[°]$	φ measured $[°]$	φ calculated $[°]$
0					
5					
10					
15					

Test bar 2: Tube Φ 6×1 mm

Load F $[N]$	Torque M_t $[N.mm]$	φ_1 measured $[°]$	φ_2 measured $[°]$	φ measured $[°]$	φ calculated $[°]$
0					
5					
10					
15					

Test bar 3: Square tube 6 × 6 × 1 mm

Load F $[N]$	Torque M_t $[N.mm]$	φ_1 measured $[°]$	φ_2 measured $[°]$	φ measured $[°]$	φ calculated $[°]$
0					
5					
10					
15					

Test bar 4: Tube Φ 6 × 1 mm

Load F $[N]$	Torque M_t $[N.mm]$	φ_1 measured $[°]$	φ_2 measured $[°]$	φ measured $[°]$	φ calculated $[°]$
0					
1					
2					
3					

3- Discussion the results and conclusion: