# Combined Bending and Torsion of a Shaft

Equivalent twisting and bending moments and the maximum shear and normal stresses in a solid round shaft under bending and torsion (Guest and Rankine).

**Method:** Textbook mechanics (Guest's maximum shear stress and Rankine's maximum normal stress theories)

## Input parameters

Unit system: SI

| Parameter | Value | Unit |
|---|---|---|
| Bending moment | 1,200.0 | N·m |
| Twisting moment (torque) | 1,600.0 | N·m |
| Shaft diameter | 60.000 | mm |
| Allowable shear stress (to size the shaft) | 50.000 | MPa |

## Calculated results

| Parameter | Value | Unit |
|---|---|---|
| Equivalent twisting moment √(M² + T²) | 2,000.0 | N·m |
| Equivalent bending moment (M + T_e)/2 | 1,600.0 | N·m |
| Maximum shear stress 16 T_e/(π d³) | 47.157 | MPa |
| Maximum normal stress 32 M_e/(π d³) | 75.451 | MPa |
| Diameter for the allowable shear stress | 58.841 | mm |

**Notes for this case**

- Static loads; shock and fatigue factors (as in the ASME shaft code) multiply M and T before combining.

## Formula and method

$$T_e = \sqrt{M^2 + T^2}, \quad M_e = \frac{1}{2}(M + T_e), \quad \tau_{max} = \frac{16 T_e}{\pi d^3}, \quad \sigma_{max} = \frac{32 M_e}{\pi d^3}$$

### Variables

| | | |
|---|---|---|
| $M$ | Bending moment | N·m |
| $T$ | Twisting moment (torque) | N·m |
| $d$ | Shaft diameter | m |
| $\tau_a$ | Allowable shear stress (to size the shaft) | Pa |
| $T_e$ | Equivalent twisting moment √(M² + T²) | N·m |
| $M_e$ | Equivalent bending moment (M + T_e)/2 | N·m |
| $\tau_{max}$ | Maximum shear stress 16 T_e/(π d³) | Pa |
| $\sigma_{max}$ | Maximum normal stress 32 M_e/(π d³) | Pa |
| $d_{min}$ | Diameter for the allowable shear stress | m |

### Method and standards

Principal stresses at the shaft surface.

### Assumptions and limits

- Solid round shaft, static. Shock and fatigue factors (K_m, K_t), keyways and other stress raisers are not applied: multiply M and T by your factors before entering them.
- d_min sizes the shaft by the maximum shear stress (Guest) only; check σ_max against the allowable normal stress (Rankine) as well.

### References

- Textbook mechanics (Guest's maximum shear stress and Rankine's maximum normal stress theories)

## Report details

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|---|---|
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| Release checks | 3 reference cases of this calculator, computed independently, are checked on every release |

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

### This calculator online

https://calc.firecad.com/mechanical/strength-of-materials/combined-bending-torsion

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.