Mechanics of Materials II:

Thin-Walled Pressure Vessels and Torsion

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Mechanics of Materials II: Thin-Walled Pressure Vessels and Torsion

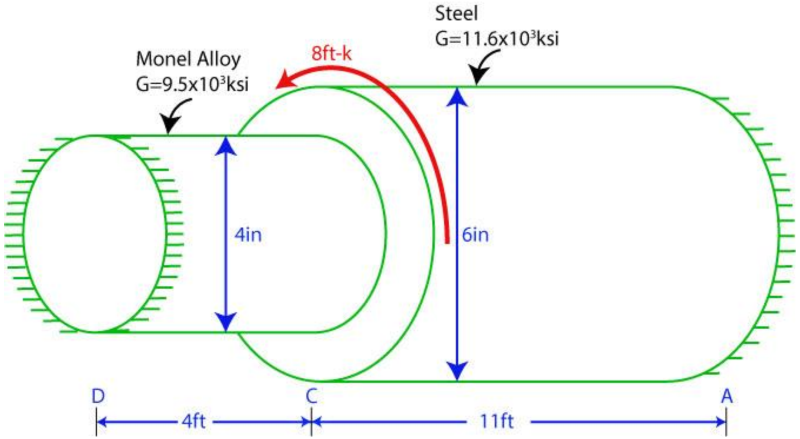
- ✓ Thin-Walled Pressure Vessels - Internal Pressure
- ✓ Torsional Shearing Stress and Strain
- ✓ Elastic Torsion Formula
- ✓ Elastic Torsion of Straight, Cylindrical Shafts
- ✓ Inelastic Torsion of Straight, Cylindrical Shafts
- ❑ Statically Indeterminate Torsion Members

Module 23 Learning Outcome

- Solve a statically indeterminate torsion problem

Statically Indeterminate Torsion

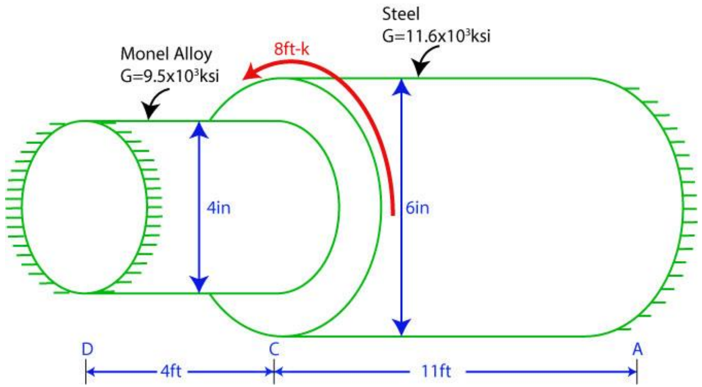
A simple model of the torsion bar of a tracked vehicle is shown below.



Statically Indeterminate Torsion

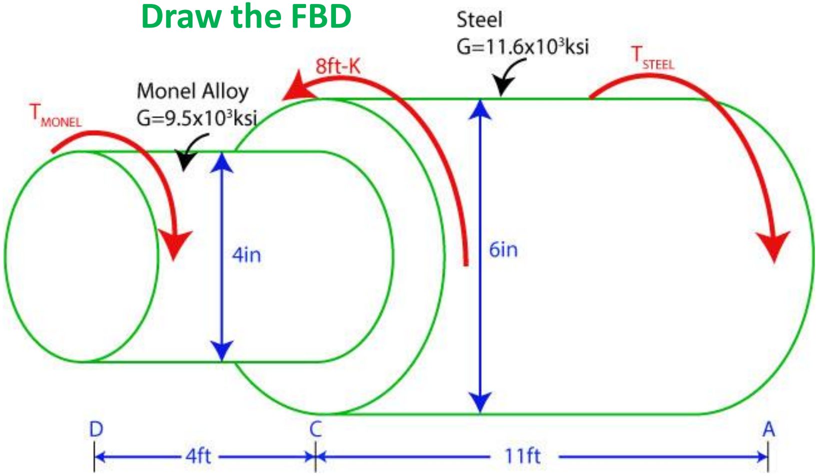
Worksheet:

Determine the maximum shear stress in each section.



Static Equilibrium Equations

Draw the FBD

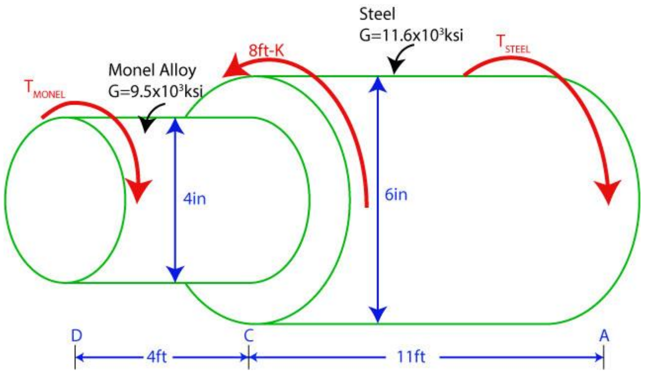


Statically Indeterminate Torsion

Worksheet: **Determine the maximum shear stress in each section.**

Static Equilibrium Equations

Draw the FBD



1 Equilibrium Equation

2 Unknowns:

T_{MONEL}, T_{STEEL}

Write the equilibrium equation to start to solve the problem

$$\sum M_z = 0$$

$$T_{MONEL} + T_{STEEL} = 8\ ft \cdot k = 96\ in \cdot k$$

EQN [1]

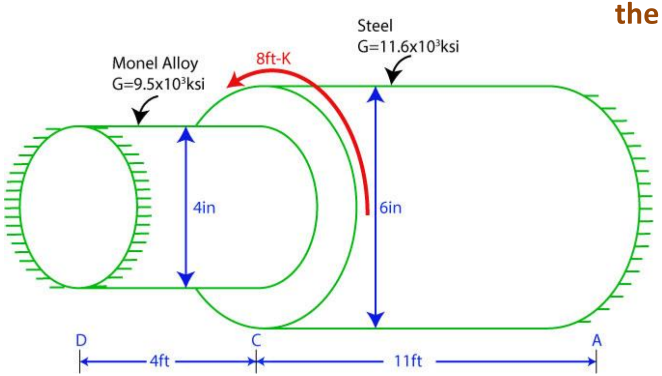
1 Equation, 2 Unknowns: T_{MONEL}, T_{STEEL}

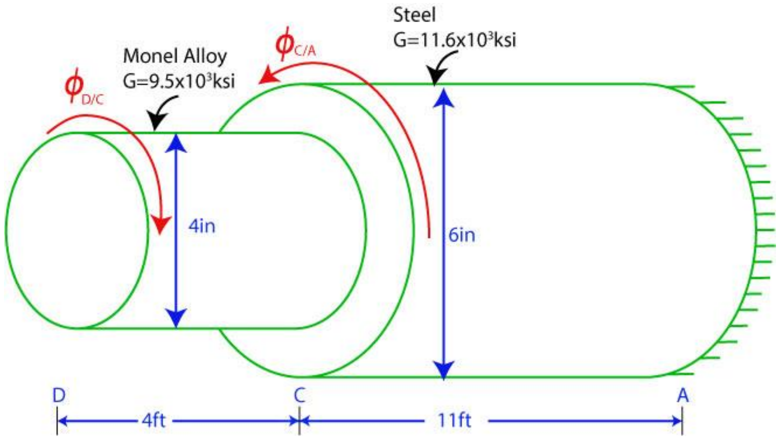
$$T_{MONEL} + T_{STEEL} = 96\ in \cdot k$$

EQN [1]

1 Equation, 2 Unknowns:

T_{MONEL}, T_{STEEL}





We need an additional equation

Deformation Equation

(geometry of the deformation of the members in the structure)

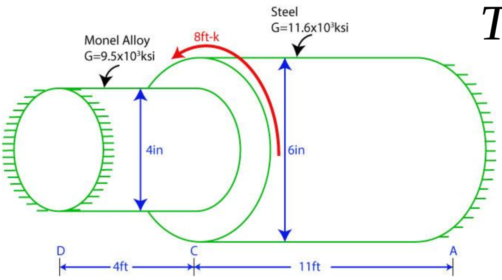
or Compatibility Equation

(compatibility between equilibrium and the deformation the structure undergoes)

$$\phi_{C/A} - \phi_{D/C} = 0$$

Let's use the elastoplastic assumption and assume the steel and monel shafts are on the linear elastic region

Worksheet: Determine the maximum shear stress in each section.



Equilibrium Equation

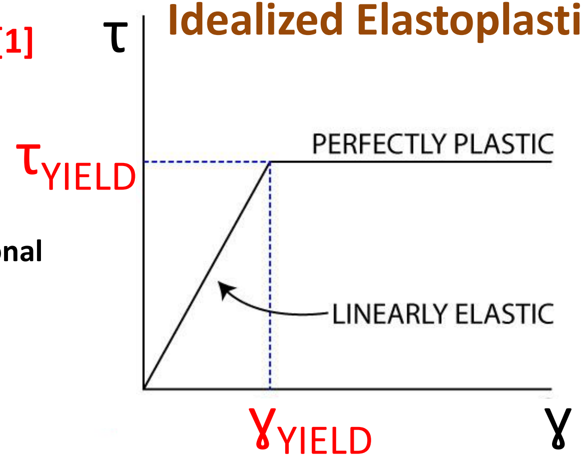
$$T_{MONEL} + T_{STEEL} = 96\ in \cdot k \quad \textbf{EQN [1]}$$

Deformation Equation

$$\phi_{C/A} - \phi_{D/C} = 0$$

Assume the steel being used has a torsional yield strength of 18 ksi, and assume the monel being used has a torsional yield strength of 25 ksi.

Idealized Elastoplastic Material

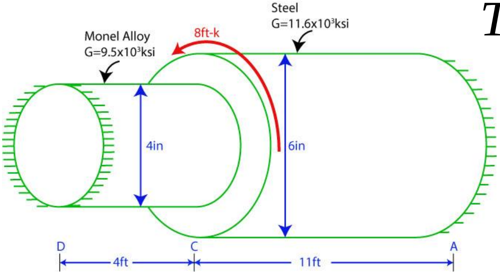


Angle of Twist, ϕ

$$\phi = \frac{T\,L}{GJ}$$

Let's use the elastoplastic assumption and assume the steel and monel shafts are on the linear elastic region

Worksheet: Determine the maximum shear stress in each section.



Equilibrium Equation

$$T_{MONEL} + T_{STEEL} = 96\ in \cdot k$$ **EQN [1]**

Assuming linear elastic region

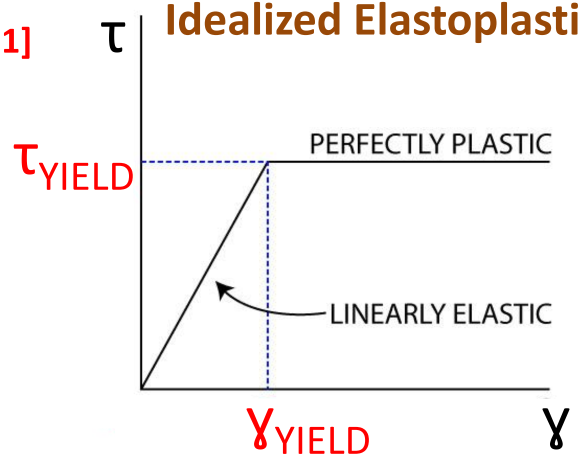
$$2.13\,T_{MONEL} = T_{STEEL}$$ **EQN [2]**

Solving simultaneously

$$T_{MONEL} = 30.7\ in \cdot k$$

$$T_{STEEL} = 65.3\ in \cdot k$$

Idealized Elastoplastic Material



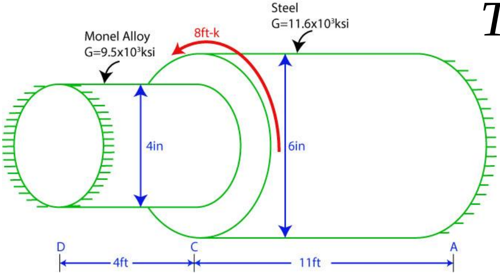
Calculate Stresses

Elastic Torsion Formula

$$\tau = \frac{T\rho}{J}$$

Let's use the elastoplastic assumption and assume the steel and monel shafts are on the linear elastic region

Worksheet: Determine the maximum shear stress in each section.



Equilibrium Equation

$$T_{MONEL} + T_{STEEL} = 96\ in \cdot k$$ **EQN [1]**

Assuming linear elastic region

$$2.13\,T_{MONEL} = T_{STEEL}$$ **EQN [2]**

Solving simultaneously

$$T_{MONEL} = 30.7\ in \cdot k$$

$$T_{STEEL} = 65.3\ in \cdot k$$

Calculate Stresses

$$\tau_{MONEL} = 2.44\ ksi$$ **ANS**

$$\tau_{STEEL} = 1.54\ ksi$$ **ANS**

Assume the steel being used has a torsional yield strength of 18 ksi, and assume the monel being used has a torsional yield strength of 25 ksi.

Check Stresses for linearly elastic assumption

Idealized Elastoplastic Material