University of Nottingham
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MMME2053
Mechanics of Solids

Combined Loading
Lecture 1

Combined Loading

Introduction

In many engineering applications, structural members are subjected to a **combination of loads**

Drawing on the knowledge of the behaviour of **individual loading cases** on **beams** and **shafts**, for example, we will consider cases where **more than one load** is applied – **combined loading**

Combined Loading

Examples

Boat Prop Shaft

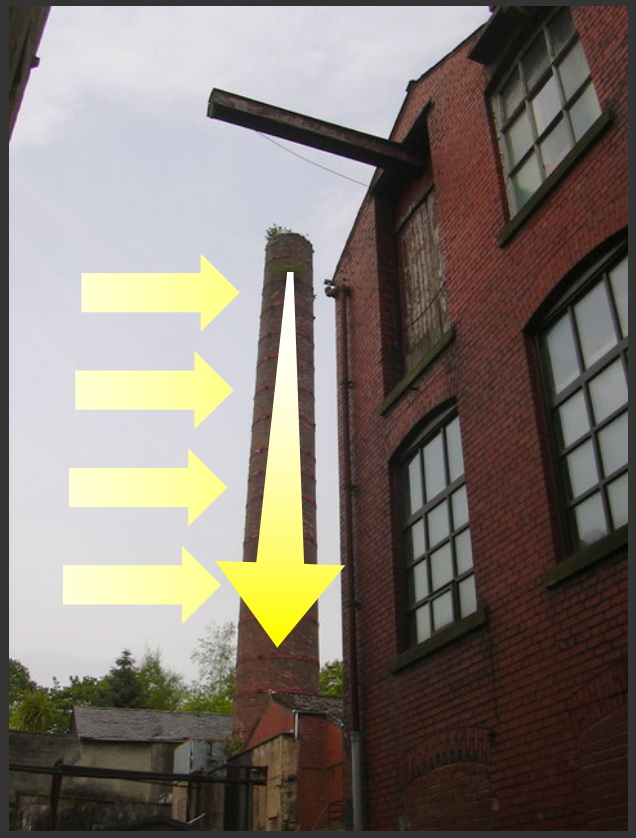
Propeller subjects the shaft to:

A compressive axial force as it pushes the water backwards

and a torsional load as it turns through the water

Combined Loading

Examples



Chimney

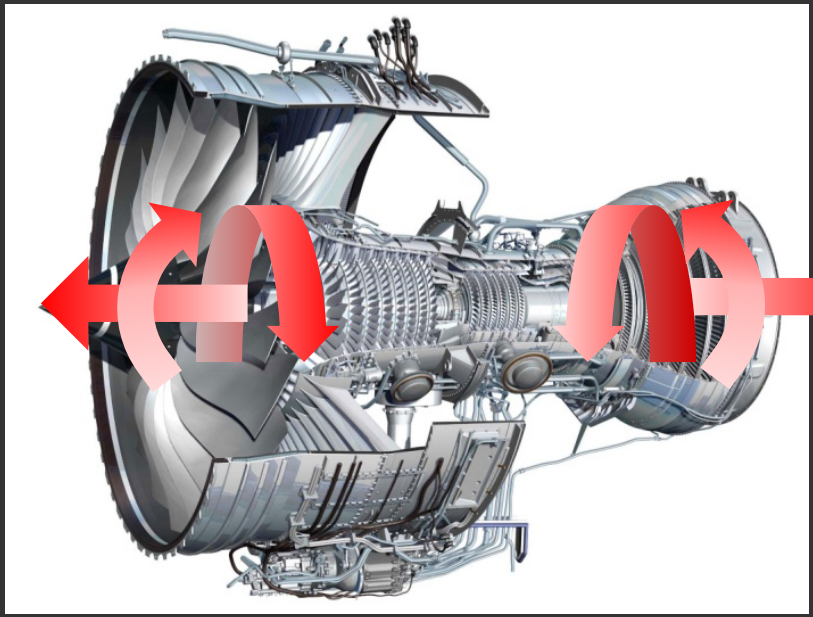
The chimney is subjected to:

A distributed axial load, due to gravity

and bending loads due to wind

Combined Loading

Examples



Aeroengine Drive Shaft

Drive shaft is subjected to:

An axial force from pushing the air backwards

and a torsional load as it turns in the air

an additional bending load is created through deformation of the casing (particularly on take off)

Learning Objectives

- Know how to use Mohr's circle to analyse a general state of plane stress (*knowledge*);

- Recognise that the effect of combined loads on a component can be analysed by considering each load as initially having an independent effect (*comprehension*);

- Employ the principle of superposition to determine the combined effect of these loads (*application*).

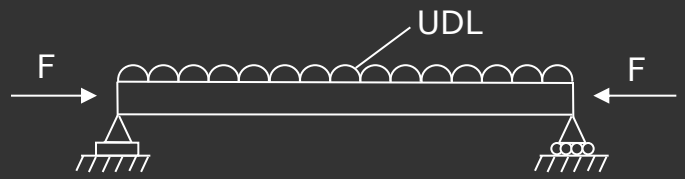
Superposition and Combined Loading

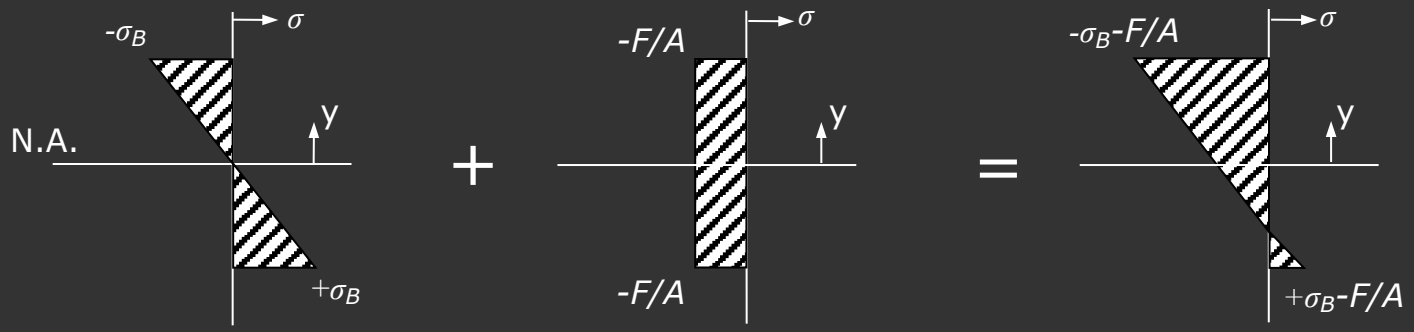
Conceptual Examples

Principal of Superposition

$$\begin{bmatrix}\textit{The total effect of combined}\\ \textit{loads applied to a body}\end{bmatrix} = \sum \begin{bmatrix}\textit{The effects of the individual}\\ \textit{loads applied separately}\end{bmatrix}$$

Combined Bending and Axial Loads



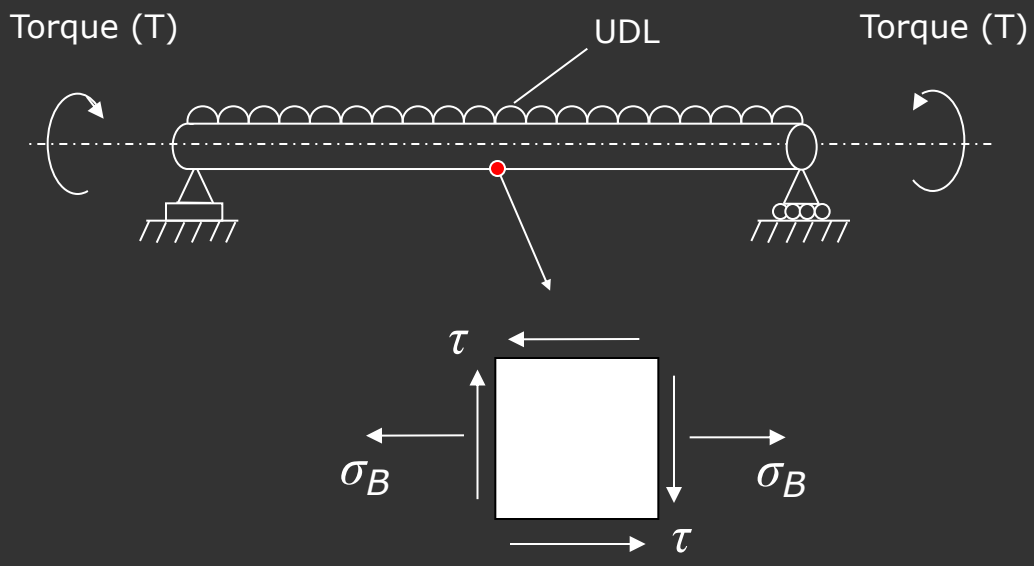


Bending only

Axial only

Resultant stress distribution

Combined Bending and Torsion



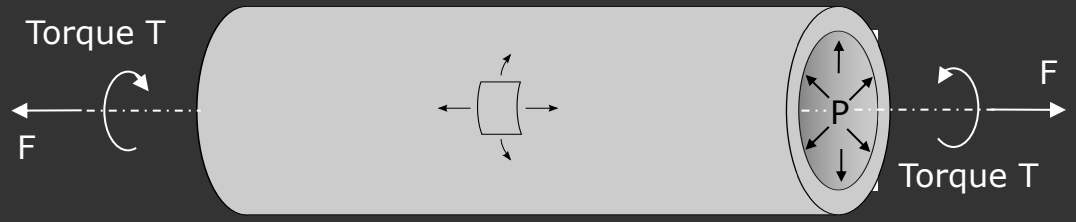
Arising from the UDL:

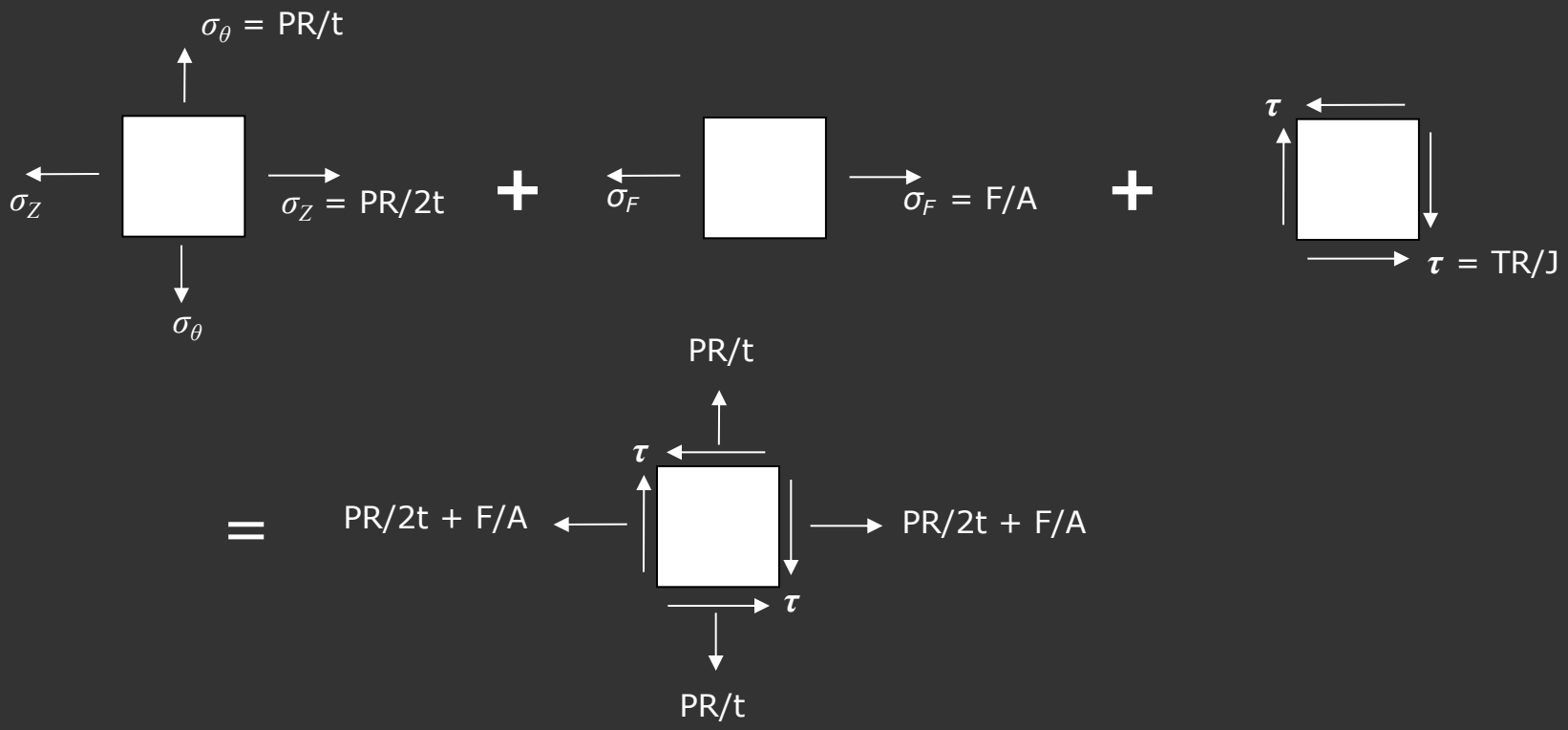
Bending stress $\sigma_B = \frac{My}{I}$ where y = d/2

Arising from the Torque:

Torsional shear stress $\tau = \frac{Tr}{J}$ where r = d/2

Combined Pressure, Axial and Torsional Loading





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