MECHANICS OF MATERIALS

Axial Load

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Chapter Description

- Expected Outcomes
  - Define the elastic deformation of an axially loaded prismatic bar
  - Define the multiple prismatic bars
  - Define the principle of superposition
  - Define the Saint – Venant's principle
  - Calculate the deformations of member under axial load
  - Calculate the deformations of member for stepped composite bar
  - Analyse the deformations in systems of axially loaded bars
  - Analyse the deformations of member for statically indeterminate assemblies.
  - Calculate the deformation of member due to temperature effect.

Introduction

- In **Chapter 1**, the concept of **stress** was developed as a mean of measuring the force distribution within a body
- In **Chapter 2**, the concept of strain was introduced to describe the deformation produced in a body
- In **Chapter 3**, discussed the **behavior** of typical engineering materials and how this behavior can be idealized by equation that relate stress and strain
- In this chapter, discussed two general approaches used to investigated a wide variety of structural member subjected to **axial loading** and **deformation**

4.2 Saint-venant's Principle

- *Saint-Venant's principle* states that both localized deformation and stress tend to "even out" at a distance sufficiently removed from these regions.

4.3 Elastic Deformation Of An Axially Loaded Member

- Using Hooke's law and the definitions of stress and strain, we are able to develop the **elastic deformation** of a member subjected to axial loads.
- Suppose an element subjected to loads,

$$\sigma = \frac{P(x)}{A(x)} \quad \text{and} \quad \varepsilon = \frac{d\delta}{dx} \quad \Rightarrow \quad \delta = \int_0^L \frac{P(x)dx}{A(x)E}$$

δ = small displacement
L = original length
P(x) = internal axial force
A(x) = cross-sectional area
E = modulus of elasticity

Constant Load and Cross-Sectional Area

- When a constant external force is applied at each end of the member,

$$\delta = \frac{PL}{AE}$$

Displacement

Sign Convention

- Force and displacement is positive when tension and elongation and negative will be compression and contraction.

4.4 Statically Indeterminate Axially Loaded Member

- A member is statically **indeterminate** when **equations of equilibrium** are **not sufficient** to determine the reactions on a member.
- Example: The bar fixed at both ends

- In order to establish, specifies the condition to **compatibility** or **kinematic** condition

4.5 THERMAL STRESS

- Change in temperature cause a material to change its dimensions
- Since the material is homogeneous and isotropic

$$\delta_T = -\alpha \Delta T L$$

α = *linear coefficient of thermal expansion*, property of the material
ΔT = algebraic change in temperature of the member
L = original length of the member
δ = algebraic change in length of the member

References

- Hibbeler, R.C., Mechanics Of Materials, 9th Edition in SI units, Prentice Hall, 2013.
- Ferdinand P. Beer, E. Russell Johnston, Jr., John T. DeWolf, David F. Mazurek, Mechanics of materials 5th Edition in SI Units, McGraw Hill, 2009.

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