I:Introduction to stress and strain

1:Introduction

- Involves the computation of stresses and strain resulting from the loads in order to establish whether or not the structure is able to withstand them.
- Only two types of stress can result:
    - Normal stress: acts perpendicular to the cross-section.
    - Shear Stress: acts tangentially to the cross-section.

2:Normal stress and strain

2.1:Normal Stress

- The simplest definition of stress is the force per unit area.
- $\sigma = \frac{F}{A}$
- All materials have their own characteristics, which determine the maximum stress they can safely withstand.
- Normal strain can be defined as the effect of applying a tensile force to a section of material.
- A sign convention is adopted that tensile stresses as positive and compressive as negatives.

2.2: Normal Strain

- $\epsilon = \frac{\Delta L}{L}$.

3:Shear Stress and Strain

3.1 Shear Stress

- Those acting tangentially to the cross section of a material.
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- The shear stress is defined as shear force(V) divided by shear area(A): $\tau = \frac{V}{A}$

3.1 Shear Strain

- Shear Strain is defined as the change in angle (radian) between two originally mutually perpendicular edges: $\gamma = \frac{\delta}{h}$, where δ is the change in length and h is the unchanged length.

4:Mechanical properties of material and stress-strain relationship (Hooke's Law)

4.1 Stress-Strain Curve

- The stress-strain curve of materials can be determined using tensile test.
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- Many materials exhibit a linear stress-strain relationship foe low values of stress.This relationship of stress being directly proportional to strain is know is Hooke's Law: $\omega = E\epsilon$, where E is referred as modulus or Young's modulus.
- Materials used in engineering can be classified as being ductile or brittle:

- In the stress-strain curve, ductile materials can undergo large strains under load before facture occurs, which have a noticeable change in the cross-section (necking) due to the approaching of the fracture(or failure).
- In contrast, brittle materials deform little before fracture, can fail suddenly without any sign.

4.2 Elastic Constants

- Young's modulus, the shear modulus and Poisson's ratio(ν) are termed as elastic constants which have such relationship:

$$G = \frac{E}{2(1+v)}$$

- Young's modulus, E, can be written as :

$$E = \frac{\sigma}{\epsilon}$$

This relationship only applies to linear region of the curve.

- Some typical values of Young's modulus:
- Shear modulus, G, is also know as rigidity and can be defined as:

$$G = \frac{\tau}{\gamma}$$

- Poisson effect / Poisson's ratio: each materials has a property termed Poisson's ratio,ν, which is the ratio of lateral strain to longitudinal strain in the elastic region of the curve:

$$\nu = -\frac{\epsilon_y}{\epsilon_x}$$

The negative sign in the expression above ensures ν is positive.

- These are some typical values of Poisson's ratio:

5:Factor of safety

- For materials defined as ductile, factor of safety is defined as :

$$n_{ductile} = \frac{yield \quad stress}{applied \quad stress} = \frac{\sigma_{ult}}{\sigma_{applied}}$$

- For brittle materials, the factor of safety can be determined as:

$$n_{brittle} = \frac{\sigma_{ult}}{\sigma_{applied}}$$

- For any type of material, if n<=1, then failure(i.e. yielding for ductile materials and fracture for brittle materials) will occur.