Mechanics of Materials

• external loads and their effect on deformable bodies
• use it to answer question if structure meets requirements of
  – stability and equilibrium
  – strength and stiffness
• other principle building requirements
  • economy, functionality and aesthetics

Knowledge Required

• material properties
• member cross sections
• ability of a material to resist breaking
• structural elements that resist excessive
  – deflection
  – deformation

Figure 2.3 (a) An example of tension on a cantilever beam.
Problem Solving

1. **STATICS:**
   - equilibrium of external forces, internal forces, stresses

2. **GEOMETRY:**
   - cross section properties, deformations and conditions of geometric fit, strains

3. **MATERIAL PROPERTIES:**
   - stress-strain relationship for each material obtained from testing

**Stress**

- stress is a term for the intensity of a force, like a pressure
- internal or applied
- force per unit area

\[
\text{stress} = f = \frac{P}{A}
\]

**Design**

- materials have a critical stress value where they could break or yield
  - ultimate stress
  - yield stress
  - compressive stress
  - fatigue strength
  - (creep & temperature)

**Design (cont)**

- we’d like
  \[
  f_{\text{actual}} << F_{\text{allowable}}
  \]
- stress distribution may very: average
- uniform distribution exists IF the member is loaded axially (concentric)
**Scale Effect**
- model scale
  - material weights, small areas
- structural scale
  - much more material weight, bigger areas
- ratio is not constant:
  \[ \frac{\gamma L^3}{L^2} = \gamma L \]

**Strain**
- materials deform
- axially loaded materials change length
- bending materials deflect
- STRAIN:
  - change in length over length
  \[ \text{strain} = \varepsilon = \frac{\Delta L}{L} \]

**Normal Stress**
- normal stress is normal to the cross section
  - stressed area is perpendicular to the load
  \[ f_{1\text{ or }c} = \frac{P}{A} \]

**Shear Stress**
- stress parallel to a surface
  \[ f_v = \frac{P}{A} = \frac{P}{td} \]

*Figure 5.7* Two columns with the same load, different stress.
*Figure 5.10* Shear stress between two glued blocks.
**Bearing Stress**
- stress on a surface by contact in compression

\[ f_p = \frac{P}{A} = \frac{P}{td} \]

**Bending Stress**
- normal stress caused by bending

\[ f_b = \frac{Mc}{I} = \frac{M}{S} \]

**Torsional Stress**
- shear stress caused by twisting

\[ f_v = \frac{T\rho}{J} \]

**Structures and Shear**
- what structural elements see shear?
  - beams
  - bolts
  - splices
  - slabs
  - footings
  - walls
    - wind
    - seismic loads
Bolts

- connected members in tension cause shear stress

- connected members in compression cause bearing stress

Single Shear

- seen when 2 members are connected

- compression & contact

- projected area

Double Shear

- seen when 3 members are connected

- two areas

\[
f_v = \frac{P}{2A} = \frac{P}{2} = \frac{P}{\pi d^2/4}
\]

Bolt Bearing Stress

- compression & contact

- projected area

\[
f_p = \frac{P}{A_{projected}} = \frac{P}{td}
\]