Chapter 6:
Experimental Characterization of Composite Materials

Objectives of Experimental Study:

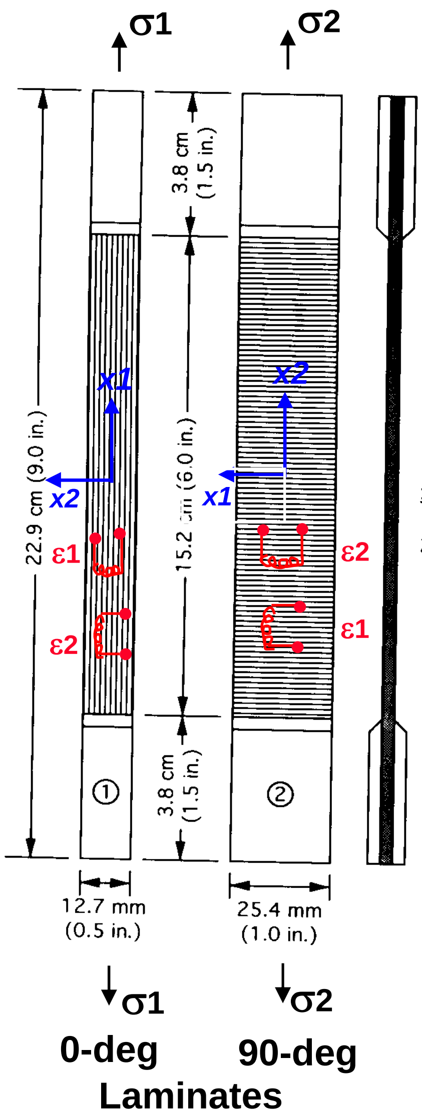
- **Determine properties of unidirectional lamina for use in structural design & analysis.**
- **Investigate & verify the analytical prediction of the mechanical behavior of structure.**
- **Independent experimental study of material and structural behavior for specific geometry & loading conditions.**

Specific Testing:

- **Characterization of constituent materials.**
- **Characterization of unidirectional lamina.**
  - **- Physical:** Density, Volume fraction, Porosity, CTE & CME
  - **- Mechanical elastic constants:** E_1, E_2, ν_{12}, and G_{12}**, & Strength:** F_{1t}, F_{2t}, F_{1c}, F_{2c}, and F_6.
- **Determination of interlaminar properties.**
- **Determination of material properties under special loading types; fatigue, creep, impact, high loading, etc.**
- **Experimental stress and failure analysis of composite laminates & structures.**
- **Assessment of structural integrity by nondestructive testing.**

Ref: ASTM standards on Testing and Materials-Vol. 15.3) D30 High modulus composite materials.
MIL Handbook

Determination of Tensile Properties
ASTM D3039/D3039M



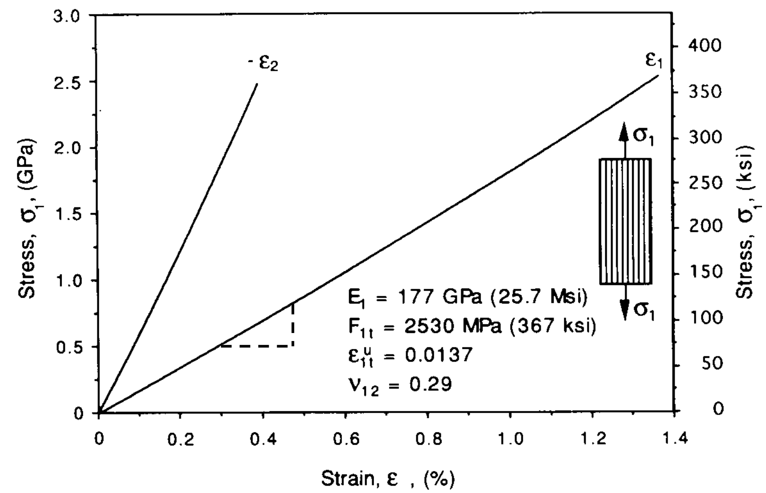
Specimen type
1. Longitudinal tensile, $[0_6]$
2. Transverse tensile, $[90_8]$

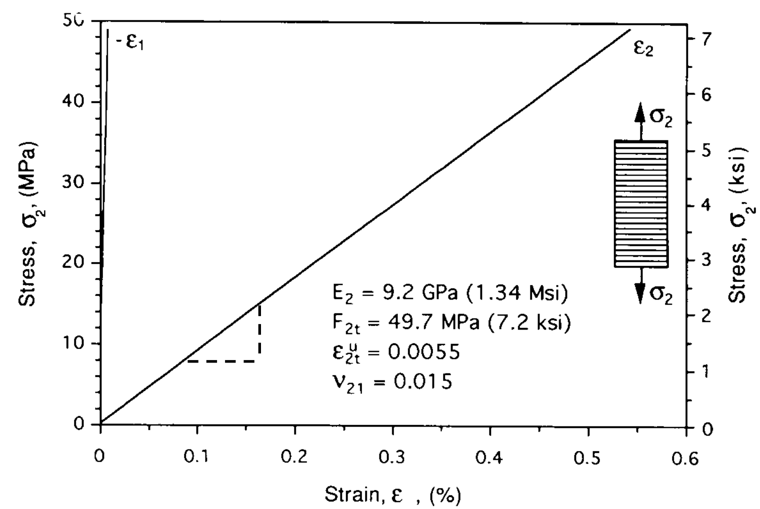
$$E_1 = \frac{\Delta\sigma_1}{\Delta\varepsilon_1}$$

$$\nu_{12} = -\frac{\Delta\varepsilon_2}{\Delta\varepsilon_1}$$

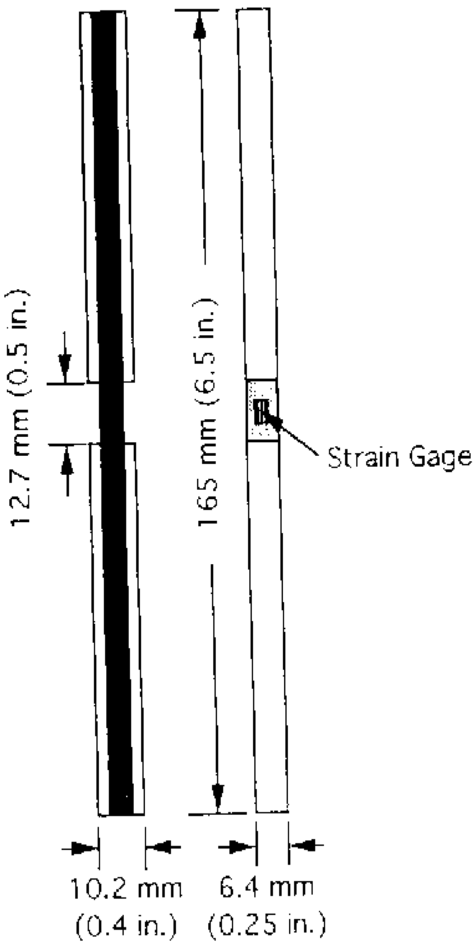
$$E_2 = \frac{\Delta\sigma_2}{\Delta\varepsilon_2}$$

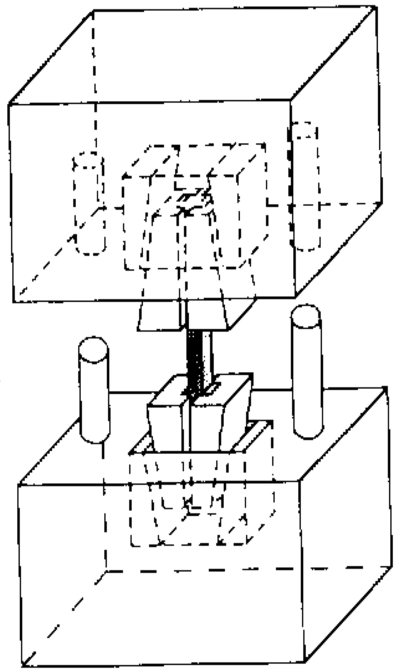
$$\nu_{21} = -\frac{\Delta\varepsilon_1}{\Delta\varepsilon_2}$$

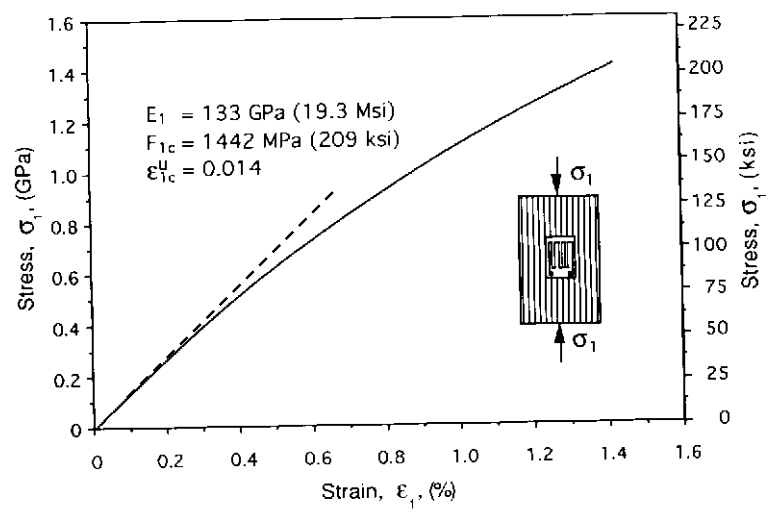




Determination of Compressive Properties
ASTM D3410M







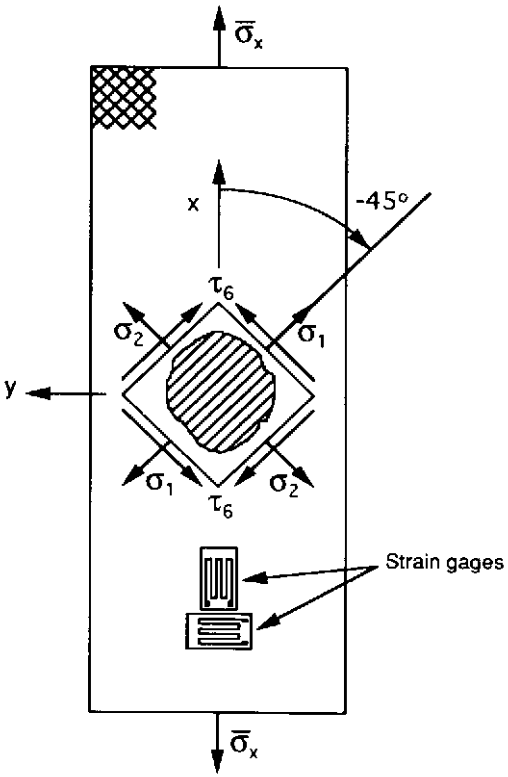
$$E_{1c} = \frac{\Delta\sigma_1}{\Delta\varepsilon_1}$$

$$\nu_{12c} = -\frac{\Delta\varepsilon_2}{\Delta\varepsilon_1}$$

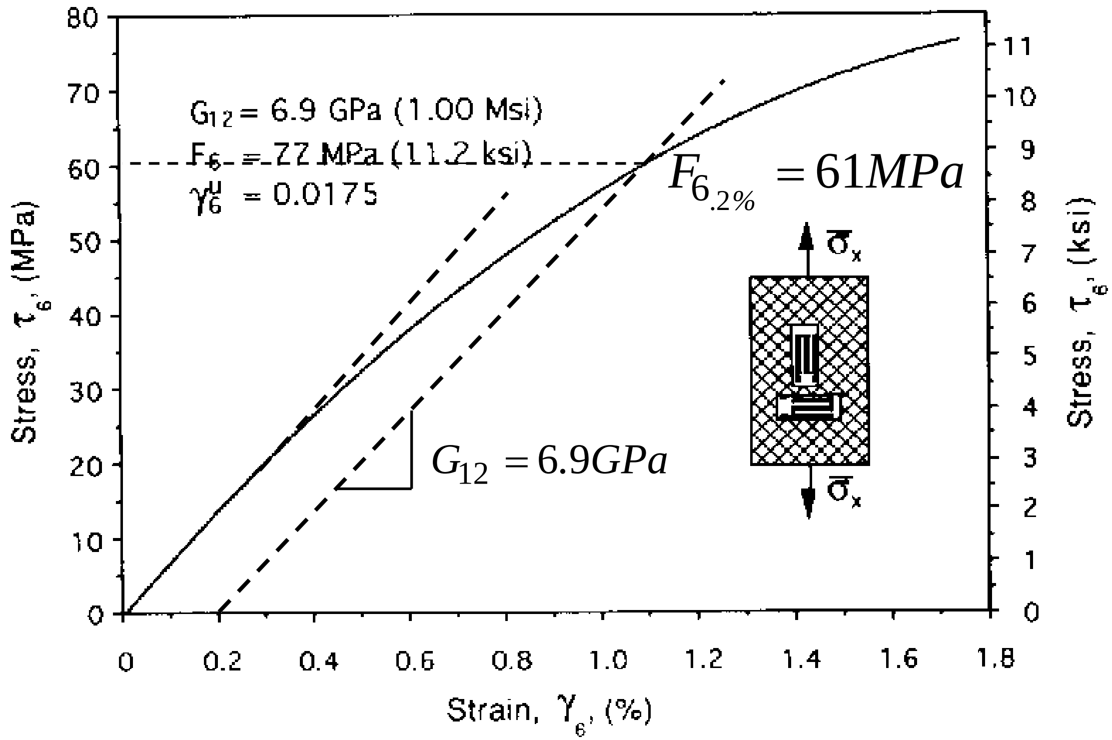
Specimen design: -- No Buckling

-- No Shear Failure

Determination of Shear Properties
ASTM D-3518M-94(2001)



($\pm$45)$_{ns}$ angle-ply laminate

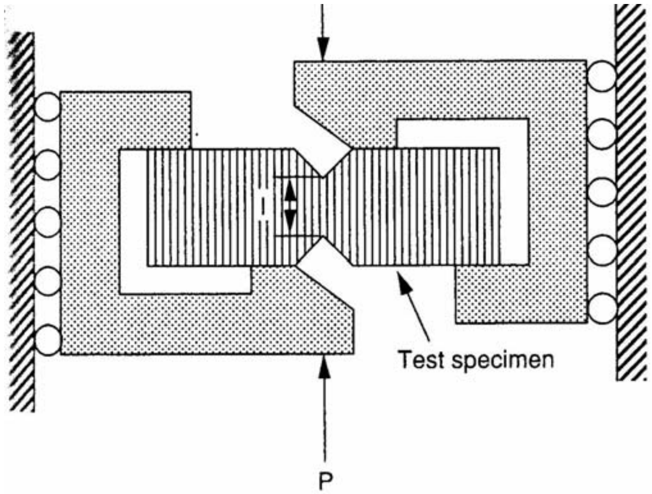


$$\Delta\tau_6 = \frac{\Delta\sigma_x}{2} \qquad \Delta\gamma_6 = \left(\Delta\bar{\varepsilon}_x - \Delta\bar{\varepsilon}_y\right)$$

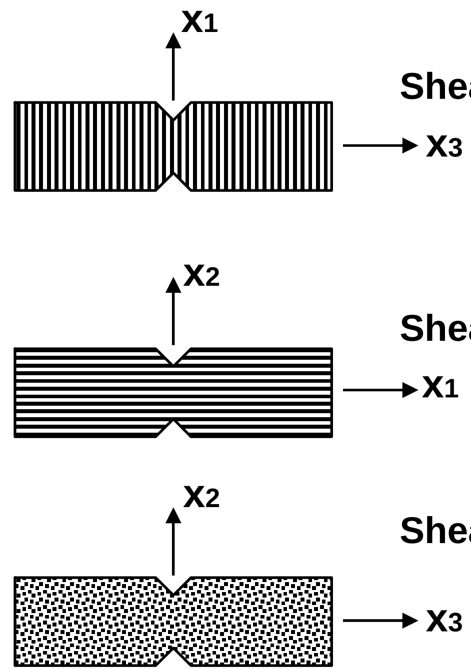
$$G_{12} = \frac{\Delta\bar{\sigma}_x}{2\left(\Delta\bar{\varepsilon}_x - \Delta\bar{\varepsilon}_y\right)}$$

$$F_{6_{0.2\%}} \text{ or } F_{6@5\%} \textit{ shear strain}$$

Iosipescu Shear Test
ASTM 5379D/5379M.



Schematic of the loading fixture



Shear modulus G_{13}

Shear modulus G_{12}

Shear modulus G_{23}

$$\tau_6 = \frac{P}{lh}$$

$$\Delta\gamma_6 = \left(\Delta\bar{\varepsilon}_{45} - \Delta\bar{\varepsilon}_{-45}\right)$$

$$G_{12} = \frac{\Delta\tau_6}{\Delta\gamma_6}$$