

Chapter 7:

Experimental Characterization of Composite Materials

Objectives of Experimental Study:

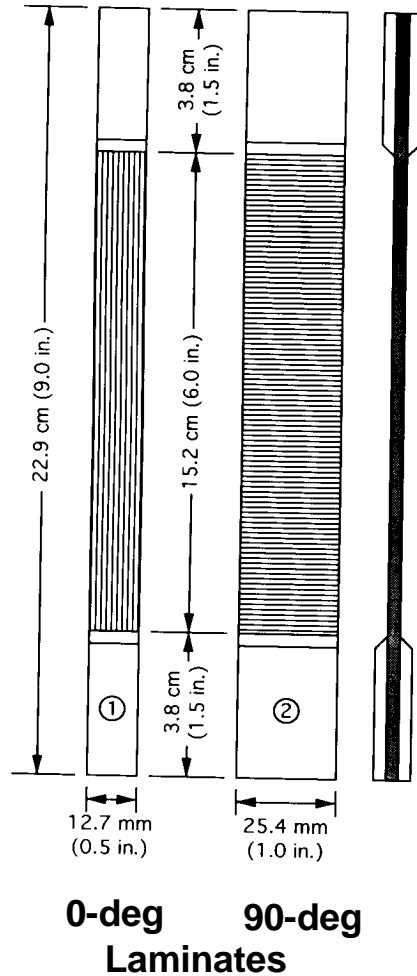
- Determine properties of unidirectional lamina for use in structural design & analysis.
- Investigate & verify the analytical prediction of the mechanical behavior of structure.
- Independent experimental study of material and structural behavior for specific geometry & loading conditions.

Specific Testing:

- Characterization of constituent materials.
- Characterization of unidirectional lamina.
 - **Physical:** Density, Volume fraction, Porosity, CTE & CME
 - **Mechanical:** E_1 , E_2 , ν_{12} , and G_{12} .
- 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



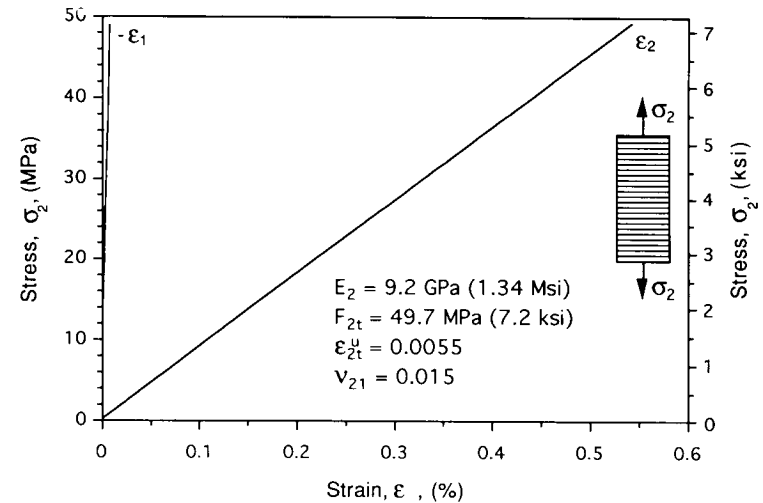
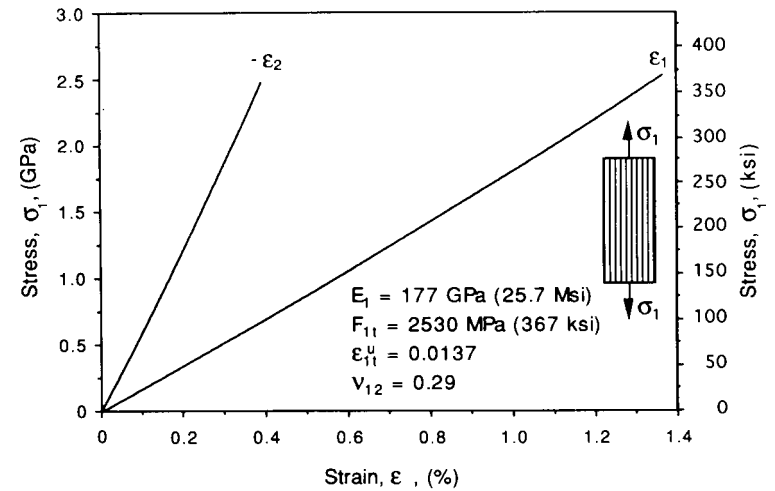
Specimen type
1. Longitudinal tensile, [0₆]
2. Transverse tensile, [90₈]

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

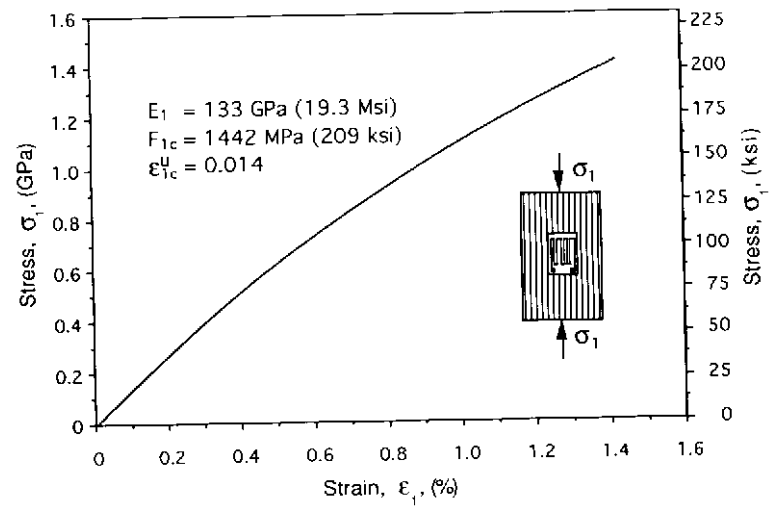
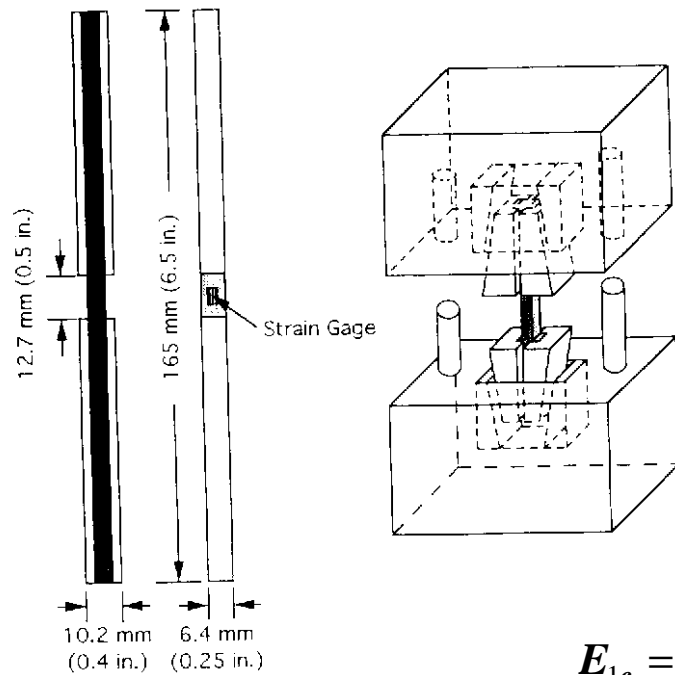
$$\nu_{12} = -\frac{\Delta\varepsilon_2}{\Delta\varepsilon_1}$$

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

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



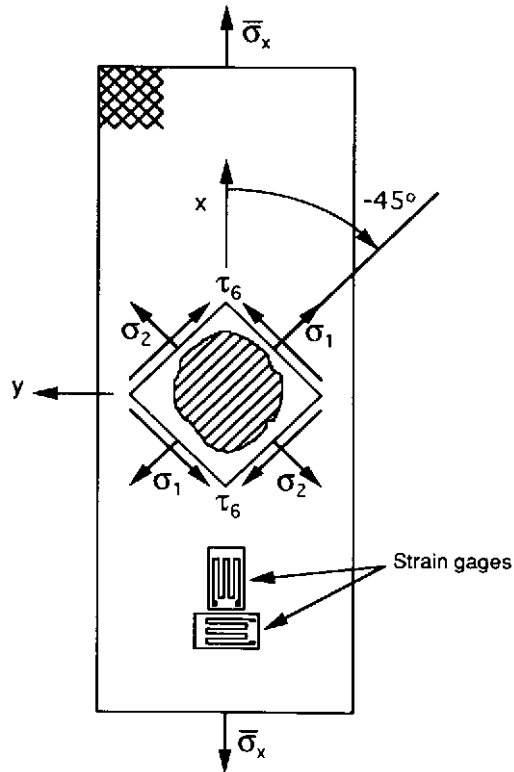
Determination of Compressive Properties



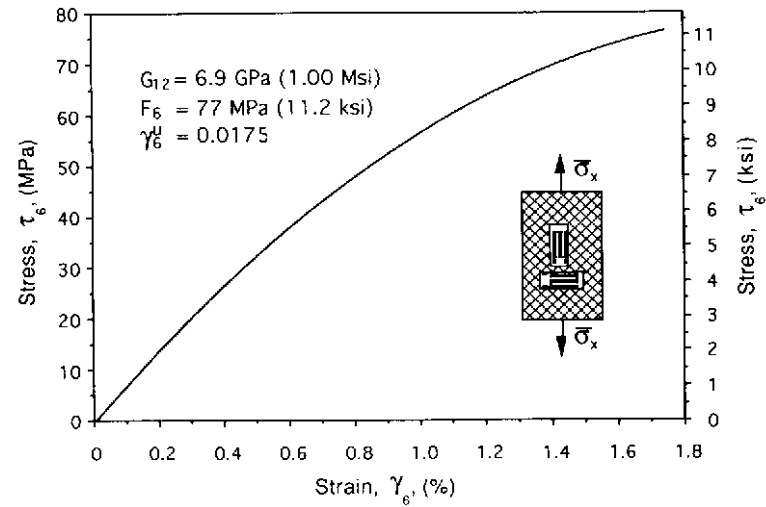
$$E_{1c} = \frac{\Delta\sigma_1}{\Delta\epsilon_1}$$

$$\nu_{12c} = -\frac{\Delta\epsilon_2}{\Delta\epsilon_1}$$

Determination of Shear Properties



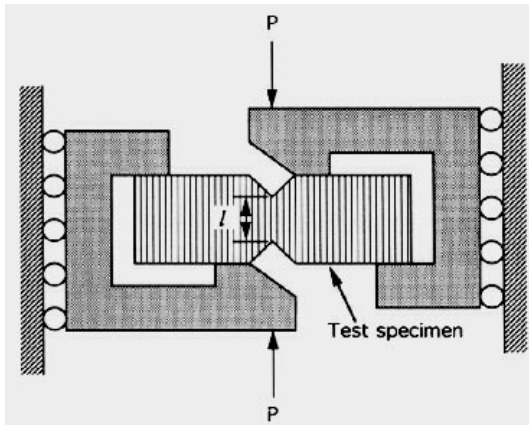
(±45)_ns angle-ply laminate



$$\Delta\tau_6 = \frac{\Delta\bar{\sigma}_x}{2} \quad \Delta\gamma_6 = (\Delta\bar{\epsilon}_x - \Delta\bar{\epsilon}_y)$$

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

Iosipescu Shear Test



Schematic of the loading fixture

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

$$\Delta\gamma_6 = (\Delta\bar{\epsilon}_{45} - \Delta\bar{\epsilon}_{-45})$$

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

