16.20 **Handed Out: Lecture 9**
Due: Lecture 12

HOME ASSIGNMENT #2

Warm-Up Exercises

1. The three-dimensional (3-D) stress-strain equations are written as:

$$\sigma_{mn} = E_{mnpq} \, \varepsilon_{pq}$$

These can be reduced for the plane stress case (i.e. $\sigma_{33} = \sigma_{13} = \sigma_{23} = 0$) to a two-dimensional (2-D) representation:

$$\sigma_{\alpha\beta} = E^{*}_{\alpha\beta\sigma\gamma} \, \varepsilon_{\sigma\gamma}$$

where the asterisk indicates that this is a 2-D elasticity tensor for plane stress whose components do not have a one-to-one correspondence with the 3-D elasticity tensor, E_{mnpq}. For an orthotropic material find the relations between $E^{*}_{\alpha\beta\sigma\gamma}$ and E_{mnpq}.

2. Repeat the previous problem for an isotropic material.

Practice Problems

3. A unidirectional graphite/epoxy composite material is loaded in the plane of its fibers. This material is transversely isotropic ($\nu_{12} = \nu_{13}$; $E_{22} = E_{33}$) and has the following four elastic constants:

$E_{11} = 130$ GPa
$E_{22} = 10.5$ GPa
$\nu_{12} = 0.28$
$G_{12} = 6.0$ GPa

The part is thin compared to its in-plane dimensions. Determine all the non-zero strain components for the following stress state:

$$\sigma_{11} = 60 \text{ MPa}$$
$$\sigma_{22} = 30 \text{ MPa}$$

Express strains in [microstrain] = 10^{-6}

4. A piece of aluminum of the same shape as the graphite/epoxy part of the previous problem is loaded in the same manner:

$$\sigma_{11} = 60 \text{ MPa}$$
$$\sigma_{22} = 30 \text{ MPa}$$

The elastic constants of the aluminum are:

$$E = 10.3 \text{ Msi}$$
$$\nu = 0.30$$

Determine all the nonzero strain components for this case.

Application Tasks

5. Beginning with the plane stress (i.e. $\sigma_{33} = \sigma_{13} = \sigma_{23} = 0$) form of the stress-strain equations:

$$\sigma_{\alpha\beta} = E^*_{\alpha\beta\sigma\gamma}\, \varepsilon_{\sigma\gamma}$$

find the relations between the five in-plane engineering constants (E_L, E_T, ν_{LT}, ν_{TL}, and G_{LT}) and the $E^*_{\alpha\beta\sigma\gamma}$ for an orthotropic material.

(**HINT:** Think compliances)

6. Repeat the previous problem for an isotropic material.