T72S01 Session 12: Thermal Stresses – Homework

Mentor Guide Questions

1.20 Explain what is meant by "thermal stress" and give examples of how thermal stresses can arise. Derive the thermal stress in a flat plate restrained from bending and subject to a linear temperature difference through the thickness.

Numerical Questions

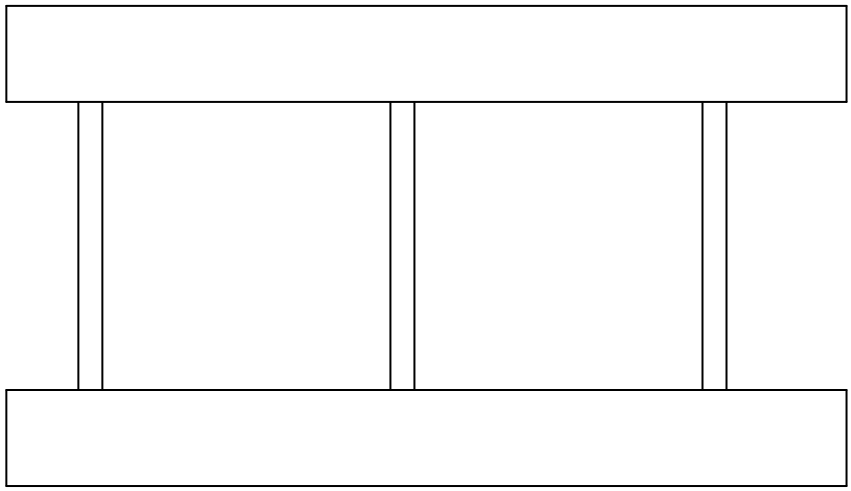
1) An initially flat plate of homogeneous, isotropic material and thickness t has a uniform through-thickness temperature gradient, $\Delta T / t$. It is unrestrained and has coefficient of thermal expansion α and elastic moduli E and ν. What is the thermal stress? Show that the radius of curvature is $\rho = \frac{t}{\alpha \Delta T}$.

2) A thin spherical shell of homogeneous, isotropic material with mean radius R and thickness t has a uniform through-thickness temperature gradient, $\Delta T / t$. It is not externally restrained and has coefficient of thermal expansion α and elastic moduli E and ν. What is the thermal stress? [Hint: use the fact that it's a *thin* shell].

3) A thin cylindrical shell of homogeneous, isotropic material with mean radius R and thickness t has a uniform through-thickness temperature gradient, $\Delta T / t$. It is not externally restrained and has coefficient of thermal expansion α and elastic moduli E and ν. What is the thermal stress?

4) A flat plate of homogeneous, isotropic material and thickness t is reduced in temperature uniformly by ΔT. The edges of the plate are fixed. The coefficient of thermal expansion is α and elastic moduli E and ν. The plate contains a through-thickness circular hole remote from its edges. What is the hoop stress at the hole?

5) Three identical bars are arranged in parallel and are connected at their ends to a pair of common rigid beams,



The central bar is raised in temperature by ΔT, everything else being unchanged. The coefficient of thermal expansion of the bars is α and their elastic moduli are E and ν. If the bars are equally spaced, what are the stresses in, (i)the outer bars, (ii)the central bar? What mode of deformation might invalidate this calculation?

6) Use R66 materials data at room temperature to find the transit time for heat through the following thicknesses of an austenitic steel, (a)3mm, (b)1cm, (c)3 inches. If one side of a constrained austenitic plate is subject to a large temperature change over a period of one minute, which of these plate thicknesses will result in large thermal stresses?