UNIVERSITY MECHANICAL ENGINEERING • EXERCISE SHEET

6.4 Beam stresses and deflection

Name: _____ Class: _____ Date: _____ **Total: 14 marks**

KEY WORDS flexure formula • deflection

Objective

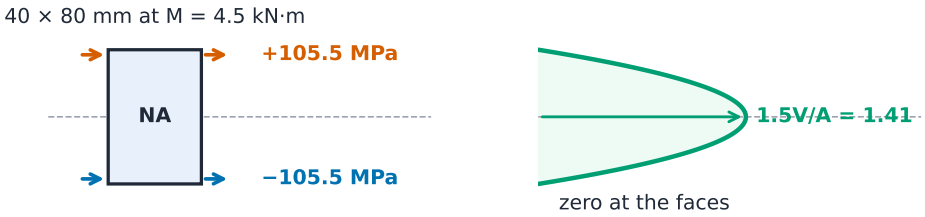
Price the beam: bending stress by the flexure formula and the section modulus, transverse shear, and deflection by the standard cases.

1 Key knowledge and worked examples

■ The stress laws and the cases

$\sigma = Mc/I = M/S$; $\tau_{max} = 1.5V/A$ for rectangles; $\delta = PL^3/48EI$ (mid-span), $PL^3/3EI$ (tip).

bending is linear in depth, shear is parabolic



*Bending linear in depth, shear parabolic

■ Worked example. The 40 x 80 arm

At $M = 4.5$ kN · m: $\sigma = 105.5$ MPa with $S = 42.7 \times 10^{-6}$ m^3; $\tau_{max} = 1.41$ MPa; mid-span $\delta = 9.89$ mm; tip case $\delta = 1.35$ mm.

2 Practice

A steel beam ($E = 200$ GPa) with the 50×100 mm rectangular section: $I = 4.167 \times 10^{-6}$ m^4, $c = 0.05$ m, $A = 0.005$ m^2.

2.1 Simply supported over 4 m with a central $P = 8$ kN: the maximum bending stress (one decimal, MPa) and the section modulus (one decimal, 10^{-6} m^3). [4]

2.2 The same beam at its maximum shear force: the maximum transverse shear stress (one decimal, MPa). [3]

2.3 The same beam and load: the mid-span deflection (one decimal, mm). [4]

2.4 The same section as a 1.5 m cantilever with $P = 1.2$ kN at the tip: the tip deflection (two decimals, mm), and the single cheapest change that would stiffen it. [3]