Example 2.2.7

A T-section cantilever beam is made of two distinct parts - one flange and one web - as shown in Figure 1. Both parts are made of the same steel with $E = 200$ GPa. The beam is 1 m long and subjected to a vertical tip load of 2 kN as shown. Before welding, the flange and the web are under frictionless contact as shown in Figure 1b. After welding, the beam behaves as a single solid section as shown in Figure 1c.

Plot the distributions of axial strains through the thickness of the beam at its built-in end, before and after welding.

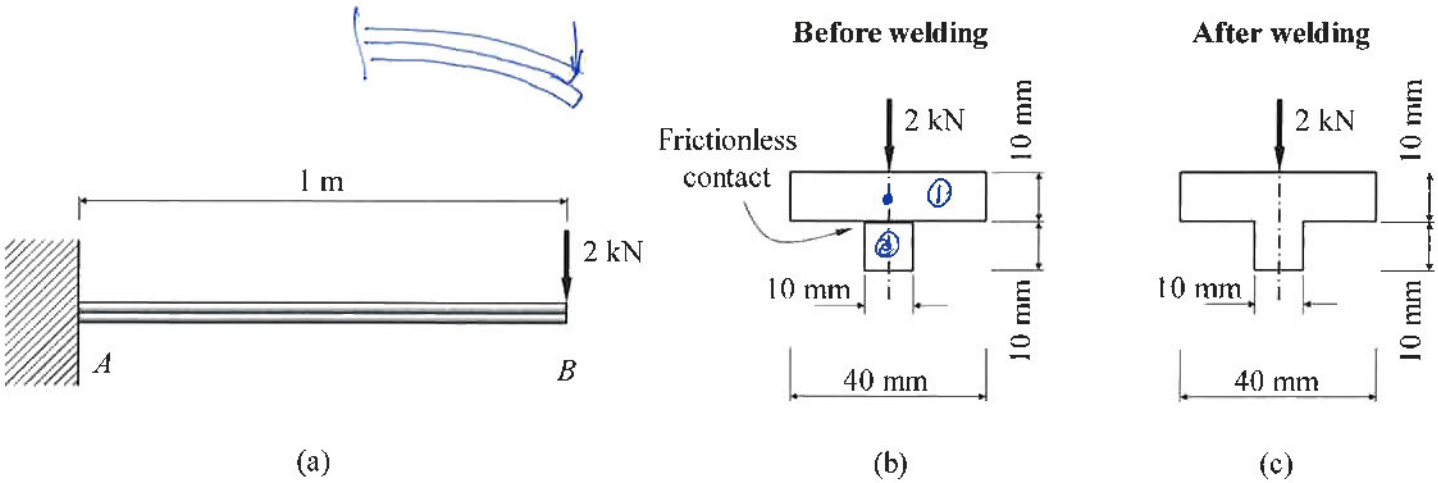


Figure 1: A T-section beam before and after welding the web on to the flange.

before) $R_1 = R_2$

$I_{comp.} = I_1 + I_2$

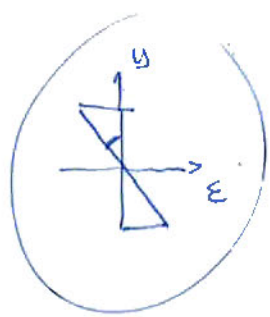
$I_i = \frac{bh^3}{12}$ → $I_1 = 3333.\bar{3}$

$I_2 = 833.\bar{3}$

$I_{comp} = 4166.\bar{6}$

$\frac{-\sigma}{y} = \frac{E}{R}$ → $\frac{-\sigma}{E} = \frac{1}{R} \cdot y$

$\sigma = E \cdot \varepsilon$ → $\varepsilon = -\frac{1}{R} \cdot y$

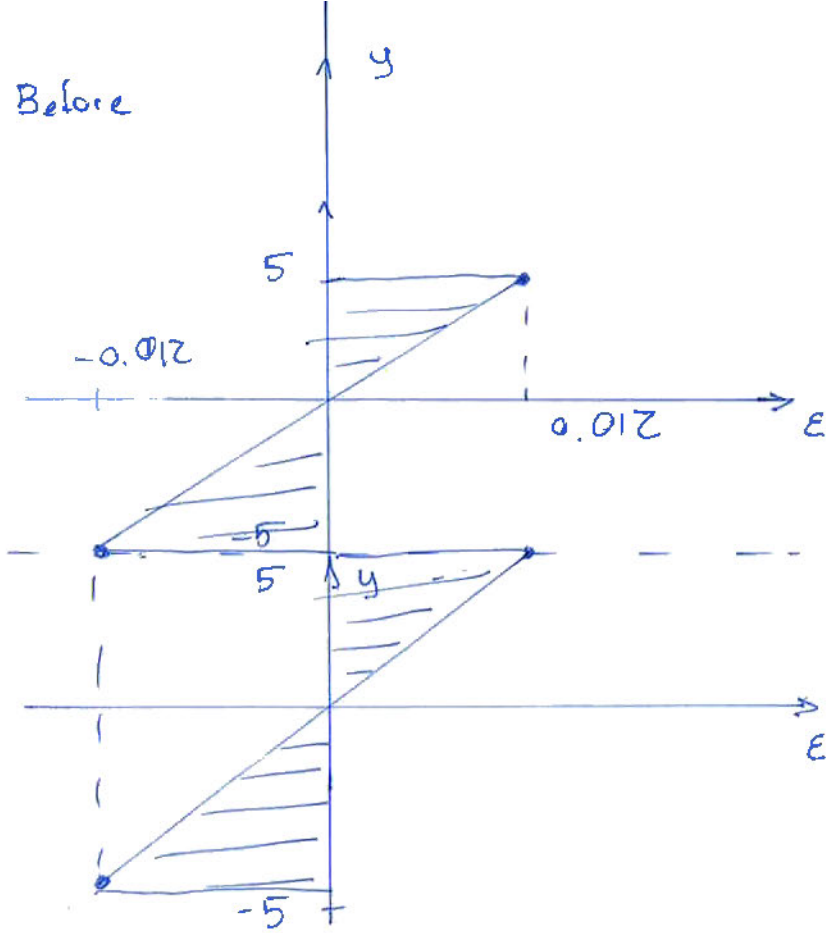


$R = \frac{EI}{M} = \frac{(200\,000)(4166)}{-2 \cdot 10^6}$

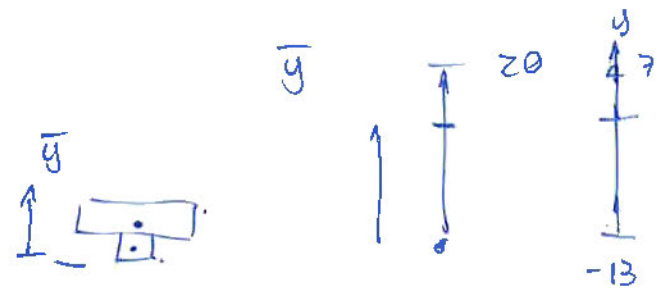
$R = -417$ mm

Before

$\varepsilon = -\frac{1}{R} y$



← Fricl. less contact

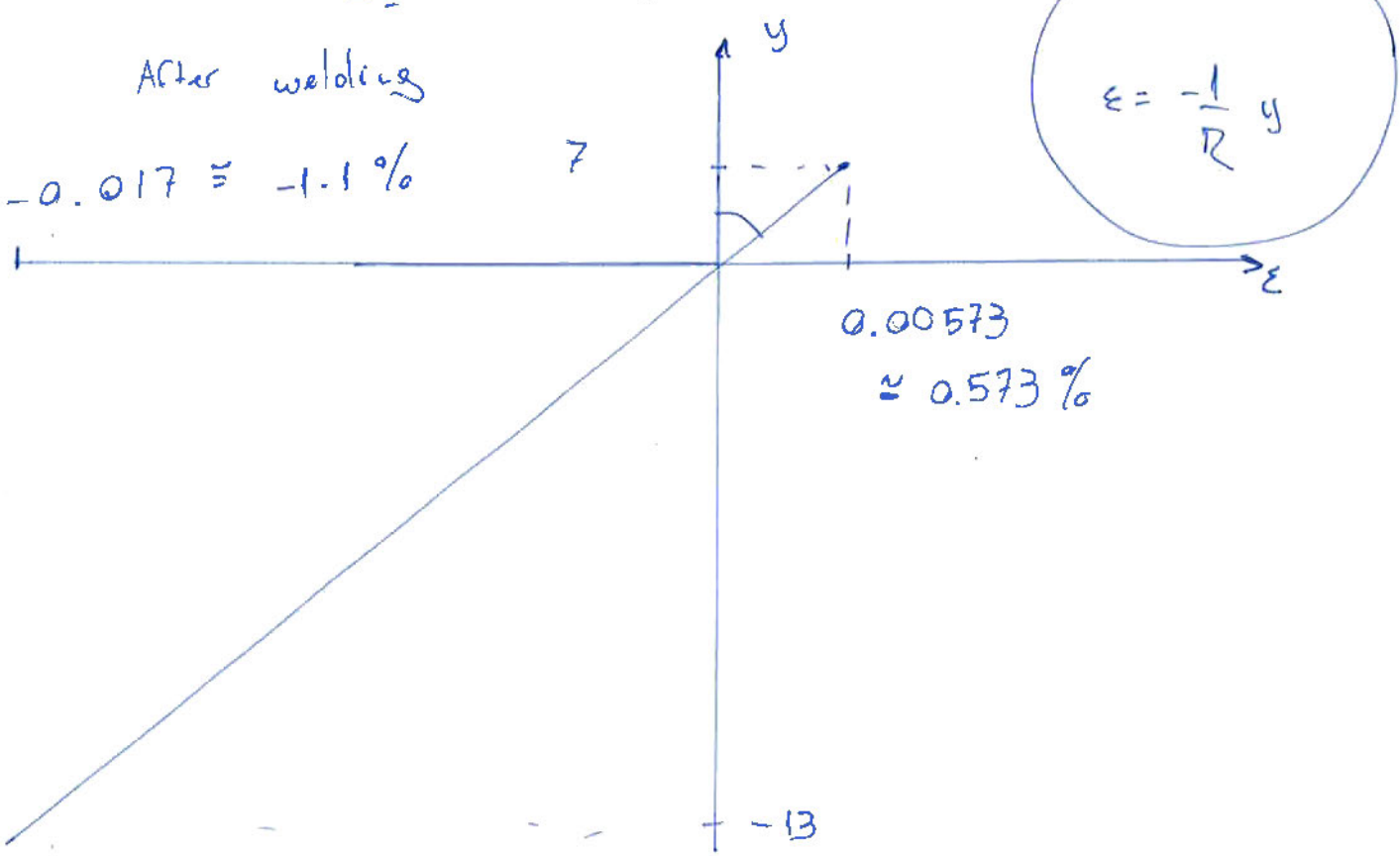


After : $\bar{y}_{NA} = 13\ mm$

$I_{NA} = 12166.\bar{6}\ mm^4$

$R = -1.22\ m$

After welding



$\varepsilon = -\frac{1}{R} y$

$-0.017 \cong -1.1\ \%$

0.00573

$\cong 0.573\ \%$