Answer of question #78565 -Physics- Mechanics - Relativity

A uniaxial steel bar is initially 200mm in length a square cross-section of 40mm X 40mm. The modulus of elasticity is 150Gpa and Poisson's ratio is 0.3, Determine the change in the dimensions of the bar when carrying a tensile load of 500KN

Input Data:

Length: $L = 2m$;

Width: $= 0.04m$;
Modulus of elasticity (Young's): $E = 150 * 10^9 Pa$;
Poisson's ratio: $\mu = 0.3$;

Tensile load $F = 500 * 10^3 N$;

Solution:

According to Hooke's law, the mechanical stress is:
$\sigma = \frac{\mathrm{F}}{\mathrm{S}}$

where S is the cross-sectional area of a square the bar:

$S = d^2$

as is known, the increment of the length of the l bar $\boldsymbol{\Delta L}$ is proportional to the mechanical stress $\boldsymbol{\sigma}$

$\Delta L = \frac{\sigma}{\mathrm{k}}$

the coefficient of proportionality $\boldsymbol{k}$, in turn, is

$k = \frac{\mathrm{E}}{\mathrm{L}}$

we obtain the length increment ΔL

$\Delta L = \frac{FL}{Ed^2}$

$\Delta L = \frac{500 * 10^3 * 2}{150 * 10^9 * 16 * 10^{-4}} = 4.2 * 10^{-3} m$

Poisson's ratio:

$\mu = -\frac{\Delta d * L}{d * \Delta L}$

hence we obtain a decrease in the thickness of the steel bar

$\Delta d = -\frac{\mu * d * \Delta L}{L}$

$$\Delta d = -\frac{0.3 * 0.04 * 0.0042}{2} = -2.52 * 10^{-5} m$$

Answer:

$$\Delta L = 4.2 mm$$

$$\Delta d = -0.0252 mm$$