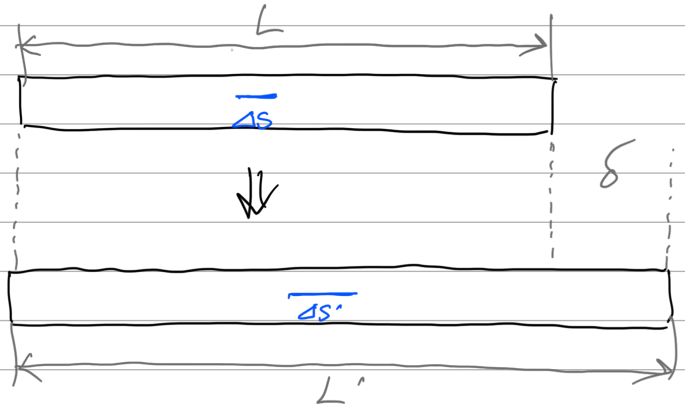
Chapter 2. Strain



Before deformation

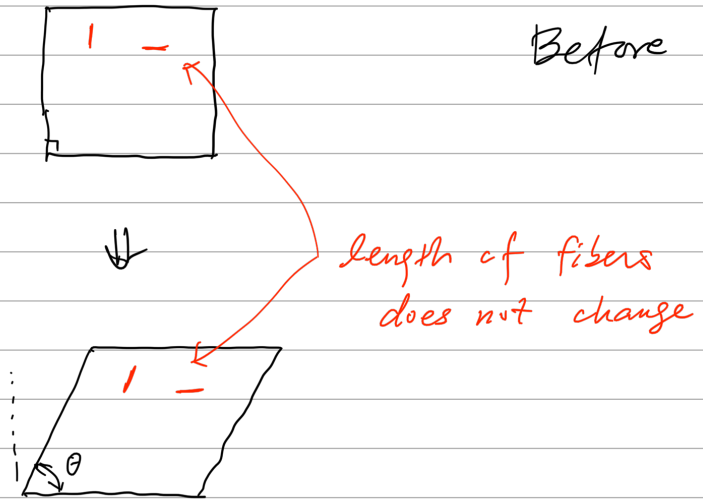
After deformation

Axial strain (normal strain)

$$\varepsilon_{avg} = \frac{L' - L}{L} = \frac{\Delta L}{L}$$

$$\varepsilon = \lim_{\Delta S \to 0} \frac{\Delta S' - \Delta S}{\Delta S}$$

Shear strain



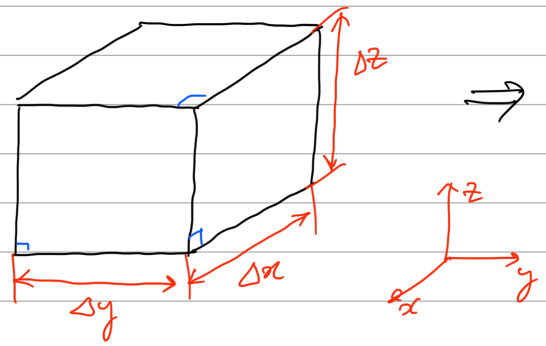
Before deformation

$$\gamma = \frac{\pi}{2} - \theta$$

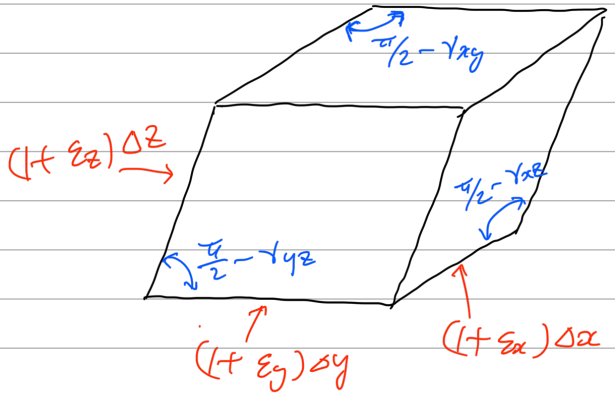
Strains are dimensionless.

State of strain

Before deformation



After deformation



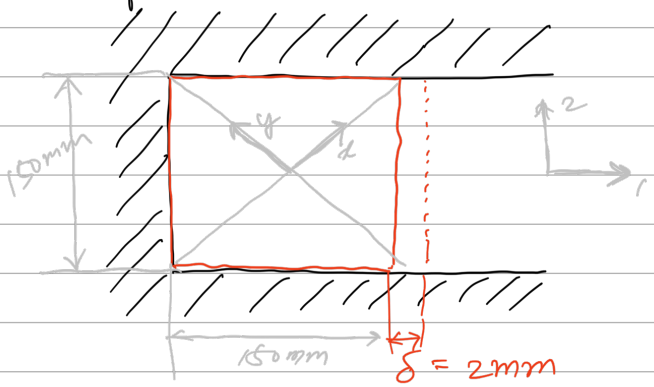
$$\Delta x' = (1+\varepsilon_x)\,\Delta x$$
$$\Delta y' = (1+\varepsilon_y)\,\Delta y$$
$$\Delta z' = (1+\varepsilon_z)\,\Delta z$$

three normal strains

$$\frac{\pi}{2} - \gamma_{xy}$$
$$\frac{\pi}{2} - \gamma_{xz}$$
$$\frac{\pi}{2} - \gamma_{yz}$$

three shear strains

Example.



A plate constrained by rigid walls

- Axial and shear strains in 1–2 directions
- Axial and shear strains in x–y directions

1 – direction

$$\varepsilon_1 = \frac{2\ mm}{150\ mm} = 0.01333 = 1.333\%$$

2 – direction

$$\varepsilon_2 = \frac{0}{150\ mm} = 0\ \%$$

1–2 direction

$$\gamma_{12} = 0$$

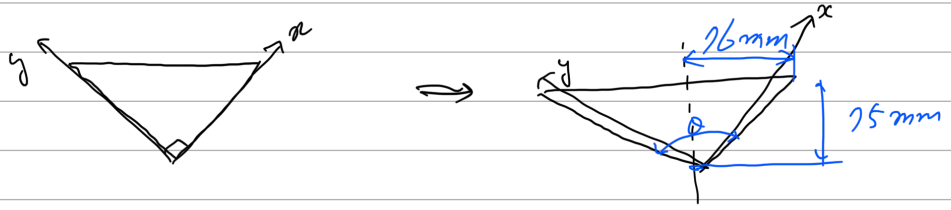
x – direction

$$\varepsilon_x = \frac{\sqrt{150^2 + 2^2} - 150}{150} = 0.00669 = 0.669\ \%$$

y – direction

$$\varepsilon_y = \varepsilon_x = 0.669\ \%$$

xy – direction



$$\tan\frac{\theta}{2} = \frac{26}{75}$$

$$\theta = 2 \cdot \operatorname{atan}\frac{26}{75}$$

$$\gamma = \frac{\pi}{2} - \theta = -0.0132\ rad \quad (-0.756^\circ)$$