Remarks: See §2.6.4, pages 40 till 42

Hint:

Calculate and draw the ε-diagram

Answers:

a. $\Delta\ell = 175$ mm
b. $\ell = 1656$ m

Explanation:

Cable length: ℓ
Cable cross-sectional area: A
Acceleration due to gravity: $g = 10$ N/kg
Define the x axis along the cable, with the origin at the hanging point.

Explanation continued:

a. Normal force in the cable:

$$N(x) = (7{,}85\times10^3 \text{ kg/m}^3)(10 \text{ N/kg})(\ell - x)A$$

Taking $\ell = 633{,}5$ m gives: $(\ell - x) = (633{,}5 \text{ m})(1-\frac{x}{\ell})$

$$N(x) = (49{,}73\times10^6 \text{ N/m}^2)(1-\frac{x}{\ell})A$$

$$\varepsilon(x) = \frac{N(x)}{EA} = \frac{(49{,}73\times10^6 \text{ N/m}^2)}{90\times10^9 \text{ N/m}^2}(1-\frac{x}{\ell}) = 0{,}552\times10^3\times(1-\frac{x}{\ell})$$

The strain varies linearly from $0{,}552‰$ in $x = 0$ to zero in $x = l$.

Draw the ε-diagram for the cable.

$$\Delta\ell = \int_0^\ell \varepsilon \text{d}x = \text{ area under the } \varepsilon\text{-diagram } = \frac{1}{2}\times(0{,}552\times10^{-3})(633{,}5 \text{ m})$$

b. $$\sigma_{\max} = \frac{N_{\max}}{A} = \frac{(7{,}85\times10^3 \text{ kg/m}^3)(10 \text{ N/kg})\cdot \cancel{A}\cdot\ell}{\cancel{A}} =$$

$$= (78{,}5\times10^3 \text{ N/m}^3)\cdot\ell \le 130\times10^6 \text{ N/m}^2 \Rightarrow \ell = 1656 \text{ m}$$