Answer on Question #59548, Physics / Mechanics | Relativity

a steel cable by which an elevator of mass 800 kg is suspended has a diameter of 2cm. the unstretched length of the suspension cable is 10 m when the elevator is on the top floor of the building. the first floor is 50 m below the top floor. find the values of extension in the cable when the elevator is on the top and on the first floor.

Find: Δl – ? ε – ?

Given:

l=60 m

m=800 kg

$d=2\times10^{-2}$ m

$E=210\times10^{9}$ N/m^2

g=9,8 N/kg

Solution:

Hooke's Law: $\sigma = E\varepsilon$ (1),

where σ – mechanical stress,

E – Young's modulus,

ε – relative elongation.

Mechanical stress: $\sigma = \frac{F_{elast}}{S}$ (2),

where F_{elast} – elastic force,

S – sectional area of the steel cable.

Elastic force numerically equal the weight of elevator:

$F_{elast} = mg$ (3)

Sectional area of the steel cable:

$S = \frac{\pi d^2}{4}$ (4)

(3) and (4) in (2):

$\sigma = \frac{4mg}{\pi d^2}$ (5)

Relative elongation: $\varepsilon = \frac{\Delta l}{l_0}$ (6),

where Δl – absolute elongation,

l_0 – initial length of cable.

Absolute elongation:

$\Delta l = l - l_0$ (7),

where l – the final length of cable

(7) in (6): $\varepsilon = \frac{l-l_0}{l_0}$ (8)

(8) in (1): $\sigma = E \times \frac{l-l_0}{l_0}$ (9)

Of (5) and (9) $\Rightarrow \frac{4mg}{\pi d^2} = E \times \frac{l-l_0}{l_0}$ (10)

Of (10) $\Rightarrow 4mgl_0 = E\pi d^2(l - l_0)$ (11)

Of (11) $\Rightarrow l_0(4mg + E\pi d^2) = E\pi d^2 l$ (12)

Of (12) $\Rightarrow l_0 = \frac{E\pi d^2 l}{(4mg+E\pi d^2)}$ (13)

Of (13) $\Rightarrow$ l_0=59,9929 m (14)

(14) in (7): Δl=0,0071 m (15)

(14) and (15) in (6): ε=0,02%

Answer:

Δ=7,1 mm

ε=0,02%