1. Two rods of different materials having coefficient of linear expansion α_1, α_2 and Young's moduli E_1, E_2respectively are fixed between to massive walls. The rods are heated such that they undergo the same increase in temperature. There is no bending of the rods. If $\alpha_1 : \alpha_2 = 2 : 3$, the thermal stresses are equal, what is the ratio of E_1 to E_2?

A. 2 : 3

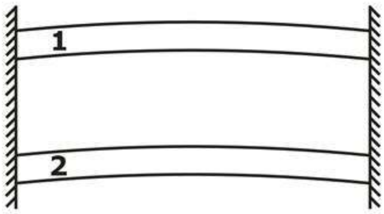
B. 1 : 1

C. 3 : 2

D. 4 : 9

Ans. C

Sol.:



Stress generated due to increase in temp may be given as,

$\sigma = \epsilon \times E = (L\ \alpha\ \Delta T)E$

$\sigma_1 = L_1\ \alpha_1\ \Delta T_1 E_1$

and $\sigma_2 = L_2\ \alpha_2 = \Delta T_2 E_2$

Given, $\sigma_1 = \sigma_2$

Also

$L_1 = L_2$ and $\Delta T_1 = \Delta T_2$

$L_1\alpha_1\Delta T_1 E_1 = L_2\alpha_2\Delta T_2 E_2$

$$\frac{\alpha_1}{\alpha_2} = \frac{E_2}{E_1}$$

$$\Rightarrow \frac{2}{3} = \frac{E_2}{E_1}$$

$$\Rightarrow \frac{E_1}{E_2} = \frac{3}{2}$$

2. A rigid block AB weighing 250 kN is supported by two rods symmetrically placed as shown in figure. The lower end of the rod are at the same level before the block is attached and temperature is changed. The stress in bronze rod after a temperature rise of 20°C

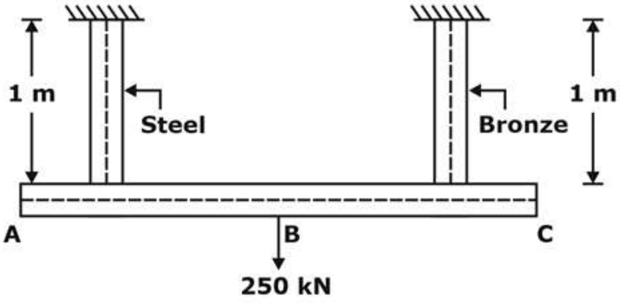
Data:

$A_s = 800\ mm^2$, $A_B = 1200\ mm^2$

$L_s = 1\ m$, $L_b = 1\ m$

$E_s = 205\ kN/mm^2$, $E_b = 82\ kN/mm^2$

$\alpha_s = 12 \times 10^{-6}\ /\ ^\circ C$, $\alpha_b = 20 \times 10^{-6}\ /\ ^\circ C$



A. 69.94 N/mm^2

B. 83.93 N/mm^2

C. 166.07 N/mm^2

D. 207.58 N/mm^2

Ans. A

Sol.: $\Delta = \Delta_{Temperature} + \Delta_{Load}$

$F_s + F_b = 250kN \quad \ldots(i)$

So,

$$L_s\alpha_s.\Delta T + \frac{F_sL_s}{A_sE_s} = L_b \cdot \alpha_b, \Delta T + \frac{F_bL_b}{A_bE_b} \qquad \ldots(ii)$$

$$1\times12\times10^{-6}\times20+\frac{F_s\times1}{205\times800}=1\times20\times10^{-6}\times20+\frac{F_b\times1}{82\times1200}$$

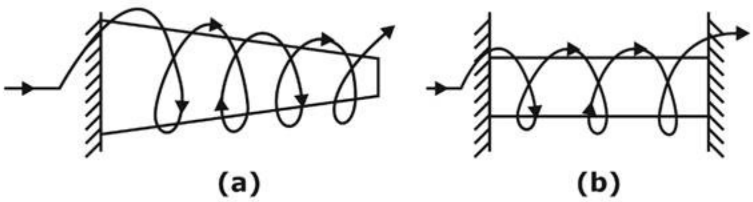
$$1\times12\times10^{-6}\times20+\frac{F_s\times1}{205\times800}=1\times20\times10^{-6}\times20+\frac{(250-F_s)\times1}{82\times1200}$$

Or, F_s = 166.067 kN

So, F_b = 83.933 kN

Stress, $\sigma_b = \frac{83.933\times1000}{1200} = 69.94N/mm^2$

3. Two arrangements are as shown below. Current is being passed through the wire which is wounded as shown in the figure. In which case thermal stress will be generated?



A. Only a

B. Only b

C. Both a and b

D. None

Ans. B

Sol.: Figure ‘b’ shows a fixed beam over which the wire is wounded. When current is passed through the wire then the beam will try to expand. However, since the ends are fixed, so expansion is restricted. Therefore, thermal stress will be generated.

4. A straight bimetallic strip made up of aluminium and steel is heated uniformly by passing current through a coil wounded over it. What can be said about the nature of stress induced?

A. Tension in both

B. Tension in aluminium, compression in steel

C. Compression in both

D. Compression in aluminium, tension in steel

Ans. D

Sol.: The thermal expansion coefficient of aluminium bar is more than Steel bar, thus while heating, aluminium bar will try to expand more as compare to the steel bar. But since both are joined rigidly,the expansion in both have to be same ,the true expansion in aluminium will be somewhat less than its free expansion.So compressive thermal stresses will develop in aluminium and Tensile Thermal stress will develop in Steel bar.

5. A bar of copper and brass form a composite system which is heated through a temperature of 50°C. The stress induced in the copper bar is ___________.

A. Tensile

B. Compressive

C. Both tensile and compressive

D. Shear

Ans. A

Sol.: The thermal expansion coefficient of copper is less than brass. $\alpha_{Brass} > \alpha_{copper}$ T

Thus, free expansion of brass will be more than copper.

But for a bimetallic strip actual expansion for both is same. Therefore, copper will experience tensile stress and brass will experience compressive stress.

6. A 100 mm × 5 mm steel bar free to expand is heated from 15°C to 40°C. Nature of the stress which will induced in the bar after heating?

A. Tensile stress

B. Compressive stress

C. Shear stress

D. No stress

Ans. D

Sol.: If a body is allowed to expand or contract freely with rise or fall of temperature then no stresses are induced in the body. If this expansion or contraction is prevented then internal resisting forces are developed. The stresses caused by these internal forces are known as thermal stresses.

7. A bar of 2m length is fixed at both ends. If E = 2 × 10^6 kg /cm^2, coefficient of expansion is 1.5 × 10^{-6} /°C and the temperature rise is 20°C, the stress developed in the material is

A. 60 kg/cm^2 (tensile)

B. 60 kg/cm^2 (compressive)

C. 60 kg/cm2 tensile of one face and 60kg/cm^2 compressive on opposite face

D. No stress is developed

Ans. B

Sol.: Given,

$E = 2 \times 10^6$ kg /cm^2,

Coefficient of expansion = 1.5×10^{-6} /°C

Temperature rise = 20°C

Stress σ = α t . E = $1.5 \times 10^{-6} \times 20 \times 20\ 10^6 = 60$ kg/m^2 (compression)

8. A circular steel rod of 20 cm^2 cross-sectional area and 10 m in length is heated through 50 °C with ends clamped before heating. Given, E = 200 GPa and coefficient of thermal expansion, α = 10×10^{-6}/ °C, the thrust thereby generated on the clamp is

A. 100 kN

B. 150 kN

C. 200 kN

D. 250 kN

Ans. C

Sol.: Thermal strain

$$\frac{\Delta l}{l} = \alpha \Delta t = 10 \times 10^{-6} \times 50 = 5 \times 10^{-4}$$

$$\text{Stress,}\sigma = \frac{\Delta l}{l} \times E = 5 \times 10^{-4} \times 200 \times 10^4 = 1000 \times 10^5 \text{N / m}^2$$

Thermal strain

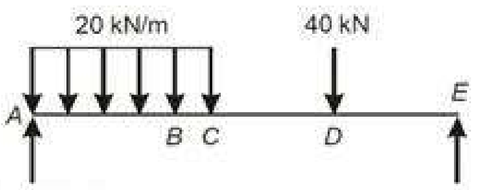
$$\frac{\Delta l}{l} = \alpha \Delta t = 10 \times 10^{-6} \times 50 = 5 \times 10^{-4} = 100 \times 10^5 \text{ N/m}^2$$

$$\text{Stress, } \sigma = \frac{\Delta l}{l} \times E = 5 \times 10^{-4} \times 200 \times 10^4$$

Force developed, F = σ.A = $1000 \times 10^5 \times 20 \times 10^{-4} = 20 \times 10^{8-4} = 20 \times 10^4$ N = 200 kN

Force developed, F = σ.A = 1000×10^5N

9. The loading diagram for a beam *ABCDE*, supported at A. Where R_A=81 kN and one more points is shown in figure(length between A to C =5 m). The maximum bending moment is _____________.



A. 164 kN-m

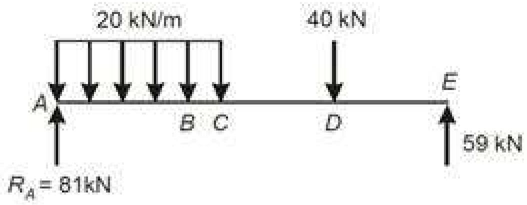
B. 185 kN-m

C. 225 kN-m

D. 284 kN-m

Ans. A

Sol.:



Given: AC = 5 m

Shear force for the section AC is gievn by:

F_{x-x} = 81 - 20x (where x is from support A such that 0 < x < 5).

As bending moment is maximum where shear force is zero. Thus:

SF = 0

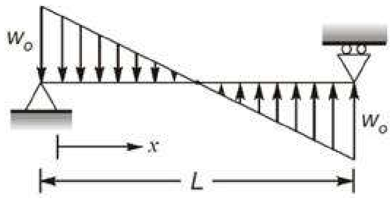
81 = 20x

x = 4.05 m

Maximum Bending Moment:

$M_{max} = 81 \times 4.05 - \frac{20 \times 4.05 \times 4.05}{2}$ = 164.025 kN-m

10. For the simply supported beam shown in the figure, the location of maximum bending moment from left hand side will be



A. 0.25 L

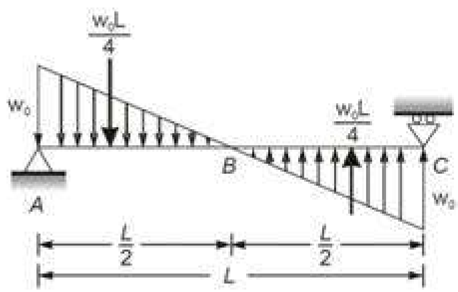
B. 0.16 L

C. 0.21 L

D. 0.50 L

Ans. C

Sol.:



Taking moment about A,

$$R_c \times L + \frac{W_0L}{4}\left(\frac{L}{2} \times \frac{1}{3}\right) = \frac{W_0L}{4}\left(\frac{L}{2} + \frac{L}{2} \times \frac{2}{3}\right)$$

$$R_c \times L + \frac{W_0L}{4}\left(\frac{L}{2} \times \frac{1}{3}\right) = \frac{W_0L}{4}\left(\frac{L}{2} + \frac{L}{2} \times \frac{2}{3}\right)$$

$$R_c \times L + \frac{W_0L^2}{24} = \frac{W_0L^2}{8} + \frac{W_0L^2}{12}$$

$$R_c = \frac{W_0L}{8} + \frac{W_0L}{12} - \frac{W_0L}{24}$$

$$\Rightarrow R_c = \frac{W_0L}{6}$$

and, $R_A + R_c = \frac{W_0L}{4} - \frac{W_0L}{4} = 0$

$\Rightarrow R_A = -R_c$

$\Rightarrow$ For bending moment to be maximum, shear force is zero.

$$(S.F_x) = \left(\frac{W_0L}{6}\right) - \frac{1}{2}\left[W_0 + \frac{(W_0)\left(\frac{L}{2} - x\right)}{\frac{L}{2}}\right] \times x$$

$$\Rightarrow \frac{L}{6} = \frac{x}{2} + \frac{x}{2} - \frac{1}{2} \times \frac{x}{L/2} \times x$$

$$\Rightarrow \frac{L}{6} = x - \frac{x^2}{L}$$

$$\Rightarrow \frac{x^2}{L} - x + \frac{L}{6} = 0$$

$$\Rightarrow x^2 - Lx + \frac{L^2}{6} = 0$$

Solving it, we get

x = 0.2132 L

11. A cantilever beam of 5m length supports a triangularly distributed load over its entire length, the maximum of which is at the free end. The total load is 21 N. what is the bending moment at fixed end?

A. **70x10³ N-mm**

B. **120x10⁶ N-mm**

C. **80x10⁶ N-mm**

D. **58.79x10⁶ N-mm**

Ans. A

Sol.: $M_x = -w/2 * x^2 + w/6L * x^3$

Maximum bending moment will be at x=L

$M_L = wL^2/3$

Total load is given which is W=wL/2 (area of triangular distributed load)

So, Bending moment at fixed end $= \frac{wl^2}{3}$

Given total load 21 kN

Total load $\Rightarrow \frac{wl}{2} = 21$

wl = 42 $= \frac{42 \times 5 \times 10^3}{3}$ = 70,000 N-mm