Solution

$L = 100\,mm, a = 10\,mm$

Hence, $Area, \quad a^2 = 100\ mm$

$$Area\ moment\ of\ inertia, \quad I = \frac{1}{12}\,a^4 = \frac{10000}{12}\ mm^4$$

$$Y_{max} = \frac{a}{2} = 5\ mm.$$

$$F_T = \pm 500\ N$$

$$F_A = 10\ kN$$

Stress due to $F_T = \pm 500\ N$

$$\sigma_{max,\ min} = \pm \frac{500 \times Y_{max} \times L}{I} = \pm 300\ MPa$$

Hence,

$$\sigma_{max} = +300\ MPa$$

$$\sigma_{min} = -300\ MPa$$

$\sigma_{amplitude}\ is\ defined\ as,$

$$\sigma_{amplitude} = \frac{\sigma_{max} - \sigma_{min}}{2} = 300\ MPa$$

Stress due to $F_A = 10\ kN$

$$\sigma_A = \frac{F_A}{A} = 10\ MPa$$

With combination, 2nd loading condition,

$$\sigma_{max} = +300 + 10\ MPa = 310\ MPa$$

$$\sigma_{min} = -300 + 10\ MPa = -290\ MPa$$

$$\sigma_a = \frac{310 - (-290)}{2} = 300\ MPa$$

$$\sigma_m = \frac{310 + (-290)}{2} = 10\ MPa$$

A

For loading condition 1,

Completely reversing

$$\sigma_A = 300\ MPa$$

From S-N curve

$$N_{f1} = 6000\ cycles$$

B

By soderberg mean stress correction

$$\sigma_{sr} = \frac{\sigma_A}{1 - \frac{\sigma_m}{\sigma_y}} = \frac{300}{1 - \frac{10}{580}} = 305.263\ MPa$$

From S-N curve

$$N_{f2} = 5000\ cycles$$

C.

Using the minor rule,

$$\sum_{i=1}^{n} \frac{N_i}{N_{fi}} = 1$$

$$\frac{N}{N_{f1}} + \frac{N}{N_{f2}} = 1$$

After putting the values

$$N = 2727\ cycles$$

Total cycle to failure = 2N = 5454 cycles.

$$Partial\ usage\ factor\ for\ load\ case\ 1 = \frac{N}{N_{f1}} = 0.45455$$

$$Partial\ usage\ factor\ for\ load\ case\ 2 = \frac{N}{N_{f2}} = 0.54545$$