Tutorial 3.1: Fastener

In-Class activity

1. State the class number of the steel bolts if the proof strength is 315 MPa.
   Answer: From table 2.2, select the next higher proof strength (380MPa). Therefore,Class 5.8 is selected.

2. Determine the preload necessary to be applied on the bolt of class 4.8 with a 6 mm diameter to form a permanent joint.

   Answer: For permanent joint, use $F_i = 0.9F_p$.
   where, $F_p = S_p A_t$
   From Table 2.2, class 4.8 has $S_p = 310MPa$
   From Table 2.1, diameter 6mm has $A_t = 20.1mm^2 = 20.1 \times 10^{-6}m^2$
   Therefore, $F_p = 310 \times 10^6 \times 20.1 \times 10^{-6} = 6.23N$
   Finally, $F_i = 0.9F_p = 0.9 \times 6.23 = 5.61N$

Theory

1. Proof strength of the steel bolts is obtained from table of specifications and strengths for steel bolts. Explain how to determine the proof strength of the bolt other than steel.

2. If the external load acting on the bolt is increasing, list ONE (1) improvement that can be done to prevent the joint from separating by assuming the diameter and class number of the bolt areunchanged.

Calculation

Question 1

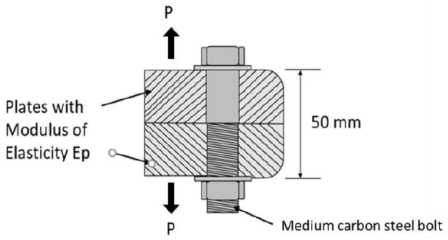

Figure 1: Figure Q1

A section of connection illustrated in Figure 1 forms a reusable connection. A total of 4 bolts are used to resist an external load 150 kN. The bolt connection is M14 x 1.5 ISO fine threadclass 5.8, made from medium carbon steel with modulus of elasticity of 200 GPa. The stress in each bolt is 406.2MPa. Determine;

(i) The joint stiffness factor.

(ii) Stiffness constant for bolt and plates.

(iii) Modulus of elasticity of plate Ep

(iv) Suggest suitable material used for plates (Based on answer in iii)

Example Solution

Reusable connection. Fi = 0.75*Fp
No. of bolt $N_{bolt} = 4$
Load = $150 \times 10^{+3} N$
d=0.014m
Pitch, p=1.5mm
Fine thread Class 5.8. From table, $S_p = 380$MPa
$E_b = 200 \times 10^{+9}$Pa
$\sigma = 406.2 \times 10^{6}$Pa
From figure, engagement length between parts, L=0.05m

i-The joint stiffness factor.

$$C = \frac{k_b}{k_b + k_p} \tag{1}$$

k_b and k_p are unknown. Find these two parameter first.
Stiffness constant for bolts, k_b

$$k_b = \frac{A_b \times E_b}{L} \tag{2}$$

Cross-sectional area for bolt,

$$\begin{aligned} A_b &= \frac{\pi d^2}{4} \\ &= \frac{\pi(0.014)^2}{4} \\ &= 1.539 \times 10^{-4} \end{aligned}$$

Substitute into Eq. 2,

$$\begin{aligned} k_b &= \frac{1.539 \times 10^{-4} \times (200 \times 10^{+9})}{0.05} \\ &= 6.158 \times 10^8 \end{aligned} \tag{3}$$

k_p cannot be determined because there are unknown values.
Find C from Total force on bolt equation.
Total force on bolt,

$$F_b = CP + F_i \tag{4}$$

Force on the bolt can be found using stress equation.

$$\sigma = \frac{F_b}{A} \tag{5}$$

$$406.3 \times 10^{+6} = \frac{F_b}{\frac{\pi(0.014)^2}{4}}$$

Force on bolt, $F_b = 62529.6N$
From Eq.4, F_i is still unknown. Find Preload, F_i

$$F_i = S_p \times A_t$$

From Table, $S_p = 380 \times 10^{+6}$ and $A_t = 125 \times 10^{-6}$

$$\begin{aligned} F_i &= 380 \times 10^{+6} \times 125 \times 10^{-6} \\ &= 35625N \end{aligned}$$

Substitute into Eq.4

$$\begin{aligned} 62529 &= C(150 \times 10^3) + 35625 \\ C &= 0.1793 \end{aligned}$$

ii - Stiffness constant for bolt and plates.
From Eq.2, Stiffness constant for bolt is $k_b = 6.158 \times 10^8$
From Eq. 1, substitue C and k_b value

$$\begin{aligned} C &= \frac{k_b}{k_b + k_p} \\ 0.1794 &= \frac{6.158 \times 10^8}{6.158 \times 10^8 + k_p} \\ k_p &= 2.817 \times 10^9 \end{aligned}$$

(No unit)

iii-Modulus of elasticity of plate Ep
From Eq of k_p

$$\begin{aligned} k_p &= \frac{0.58\pi E_p d}{2\ln\left(5\frac{0.58d+0.5l}{0.58d+2.5l}\right)} \\ &= 2.817\times10^9 = \frac{0.58\pi E_p 0.014}{2\ln\left(5\frac{0.58(0.014)+0.5(0.05)}{0.58(0.014)+2.5(0.05)}\right)} \\ &= 2.284\times10^{11} \\ &= 228.4GPa \end{aligned} \tag{6}$$

iv - Suggest suitable material used for plates (Based on answer in iii)