

Calculation of Safety Factor for each Bracket Mounting Bolt diameter & thread size. PART C

Analysis:

(i) Calculating Minimum Allowable Shear Stress Area (A_s):

The 4 bolts used will be picked because of their characteristic of not having any thread in the cross section of the areas being clamped. They are also being used because of their ability to withstand shear, and also be able to withstand tensile failure caused by weak threads.

The two possibilities of failure will be checked for their minimum allowable bolt size, and the larger of the two used for the overall minimum allowable bolt-size.

Let angle of resultant tension bar force be θ

$$\theta := 31.0 \text{deg}$$

Let maximum vertical component force of Tension bar be F_{\max}

$$F_{\max} := 2459 \text{lb} \cdot \sin(\theta)$$

$$F_{\max} = 1.266 \times 10^3 \text{lb}$$

Assume SAE Grade 5 Steel for material.

$$S_y := 92000 \cdot \frac{\text{lb}}{\text{in}^2}$$

$$\tau_d := \frac{S_y}{2}$$

$$\tau_d = 4.6 \times 10^4 \frac{\text{lb}}{\text{in}^2}$$

Minimum required shear area for each of 4 bolts:

$$\tau_d \geq \frac{F_{\max}}{4 \cdot A}$$

$$A_s := \frac{F_{\max}}{4 \cdot \tau_d}$$

$$A_s = 6.883 \times 10^{-3} \text{in}^2$$

(i) Calculating Minimum Allowable Tensile Stress Area (A_t):

Maximum load shared by each of the four bolts in tension:

$$F_{\max} := \frac{2459 \cdot \text{lb} \cdot \cos(\theta)}{4}$$

$$F_{\max} = 526.944 \text{ lb}$$

SAE Grade 5 Steel for material proof strength is:

$$P_s := 85000 \cdot \frac{\text{lb}}{\text{in}^2}$$

Allowable tensile stress is 75% of proof strength:

$$\sigma_d := \frac{75}{100} \cdot P_s$$

$$\sigma_d = 6.375 \times 10^4 \frac{\text{lb}}{\text{in}^2}$$

$$\sigma_d \geq \frac{F_{\max}}{A_T}$$

Minimum required tensile area for each bolt is:

$$A_t := \frac{F_{\max}}{\sigma_d}$$

$$A_t = 8.266 \times 10^{-3} \text{ in}^2$$

From Table 18-4 (A), the standardized area for 0.008266 in^2 is 0.00909 in^2 .

Case G: Fluctuating Normal Stresses: The Soderberg Criterion : will be used to compute the safety factor (**N**) If the safety factor is OK, then the corresponding diameter and thread size will be specified for each bracket mounting bolt.

The decision is to design for a Safety Factor (**N**) of 4, as the material is ductile, with uncertain stress analysis regarding shock or impact loading. The formula is:

$$N = \frac{1}{\left(\frac{\sigma_m}{S_y} + Kt \cdot \frac{\sigma_a}{S_{n1}} \right)}$$

$$F_{\max} = 526.944 \text{ lb} \quad F_{\min} := 215 \cdot \text{lb} \cdot \frac{\cos(\theta)}{4} \quad F_{\min} = 46.073 \text{ lb}$$

Design decision: Table 18-4(B) try $\phi .375$ in with tensile stress area of 0.0775 in^2

$$\sigma_{\max} := \frac{F_{\max}}{A_1}$$

$$\sigma_{\max} = 6.799 \times 10^3 \frac{\text{lb}}{\text{in}^2}$$

$$A_1 := .0775 \text{ in}^2$$

$$\sigma_{\min} := \frac{F_{\min}}{A_1}$$

$$\sigma_{\min} = 594.487 \frac{\text{lb}}{\text{in}^2}$$

N = Safety Factor, σ_m = mean stress,
Sy = yield strength, **kt** = stress concentration,
 σ_a = alternating stress,

$$\sigma_m := \frac{\sigma_{\max} + \sigma_{\min}}{2}$$

$$\sigma_m = 3.697 \times 10^3 \frac{\text{lb}}{\text{in}^2}$$

Sn1 = Estimated actual endurance strength.

$$\sigma_a := \frac{\sigma_{\max} - \sigma_{\min}}{2}$$

$$\sigma_a = 3.102 \times 10^3 \frac{\text{lb}}{\text{in}^2}$$

$$S_n := 30000 \frac{\text{lb}}{\text{in}^2}$$

$$S_y := 92000 \cdot \frac{\text{lb}}{\text{in}^2}$$

$$C_s := 1 \quad \text{Assume Dia.} = .375 \text{ in}$$

$$C_m := 1$$

$$C_{st} := 0.8$$

$$C_R := 0.81$$

$$Kt := 1$$

$$S_{n1} := S_n \cdot (C_s) \cdot (C_m) \cdot (C_{st}) \cdot (C_R)$$

$$S_{n1} = 1.944 \times 10^4 \frac{\text{lb}}{\text{in}^2}$$

$$N := \frac{1}{\left(\frac{\sigma_m}{S_y} + \frac{Kt \cdot \sigma_a}{S_{n1}} \right)}$$

$$N = 5.006$$

O.K. .375in - 16 UNC will be used.

In Conclusion :After trying several different bolt sizes along with different materials I found that this was the closest I could get to a safety factor of 4 I could get.