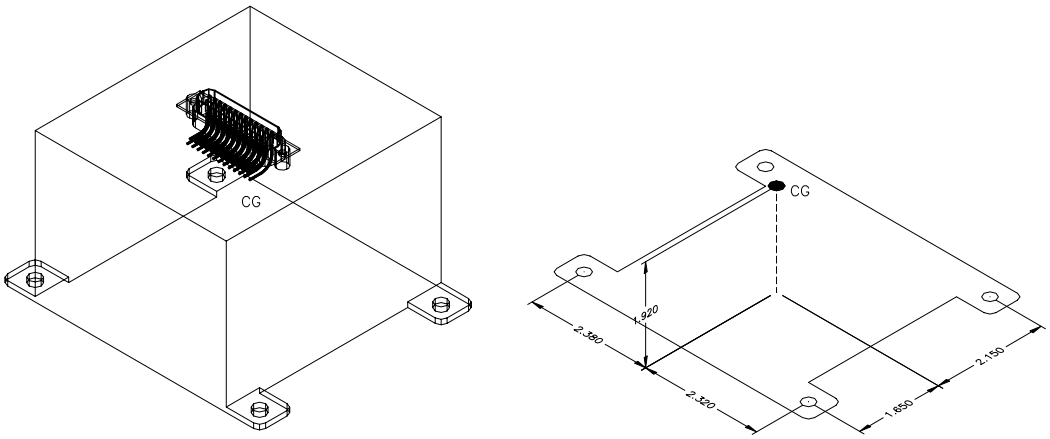
I am trying to calculate the stresses each bolt experiences from a vibration table shaking the product at 20g on each of the three axis. There are four screws holding down the unit. I am trying to compare the stresses that the screws will experience if I used .25 dia screws and if I used .1875 dia screws. It is the diameter of the shank I am analyzing, not the thread. I believe I calculated the tensile and shearing stresses correctly, but calculating the stress due to the torsion produced in each screw by the load comes up with huge numbers. Any help would be greatly appreciated

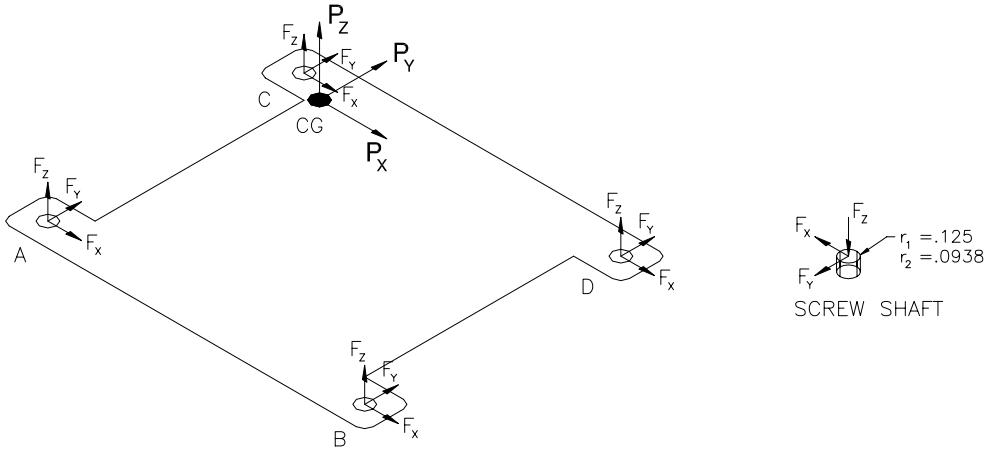


It is assumed the unit acts as a rigid body and that, due to the relative centricity of the center of gravity, that the load applies equally to each of the four screws. Therefore, the tensile and shearing forces on each screw will be represented by:

$F_x = (1/4)P_x$

$F_y = (1/4)P_y$

$F_z = (1/4)P_z$



The load applied is an ultimate load case at 20g acceleration in the lateral, longitudinal and vertical directions. The weight of the unit is assumed to be 2.80 lbs maximum, resulting in a force of $56lb_f$ for each direction tested.

Each stress is calculated for two different fasteners, one with a .250 dia shaft and one with a .1875 dia shaft.

r_1 = .125 in (FTK7059-12-17)
r_2 = .0938 in (FTK7161-12-17)

A_1 = .0491 in^2
A_2 = .0276 in^2

Tensile and shearing stresses
Assuming the forces apply equally on each screw;
For the lateral (X-direction) shake:
$P_x = 56lb_f$
$P_y = 0$
$P_z = 0$

$F_x = 14lb_f$
$\tau = F/A$
τ_1 = 285.1 psi
τ_2 = 507.2 psi

For the longitudinal (Y-direction) shake:
$P_x = 0$
$P_y = 56lb_f$
$P_z = 0$

$F_y = 14lb_f$
τ_1 = 285.1 psi
τ_2 = 507.2 psi

For the vertical (Z-direction) shake:
$P_x = 0$
$P_y = 0$
$P_z = 56lb_f$

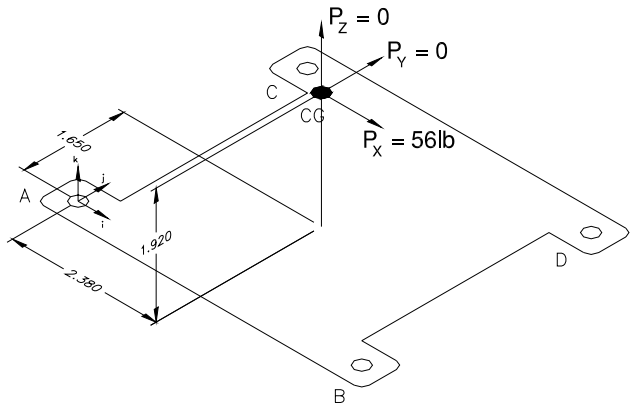
$F_z = 14lb_f$
$\sigma = F/A$
σ_1 = 285.1 psi
σ_2 = 507.2 psi

The maximum tensile stress (σ) in the smaller screw is 0.51 ksi, well below the UTS of 67.3 ksi.

The ultimate shearing stress (USS) for steel is approximately 0.75UTS. The maximum shearing stress (τ) in the smaller screw is 0.51 ksi, well below the USS of 50.48 ksi.

Shearing stresses caused by torsion
The torsion on each screw caused by the loading in each direction would be as follows:

<u>For the lateral (X-direction) shake:</u>
• For the moment about Screw A:



$P = 56i + 0j + 0k$
$n = 2.38i + 1.65j + 1.92k$

$$M_A = P \times n = \begin{vmatrix} i & j & k \\ 56 & 0 & 0 \\ 2.38 & 1.65 & 1.92 \end{vmatrix}$$

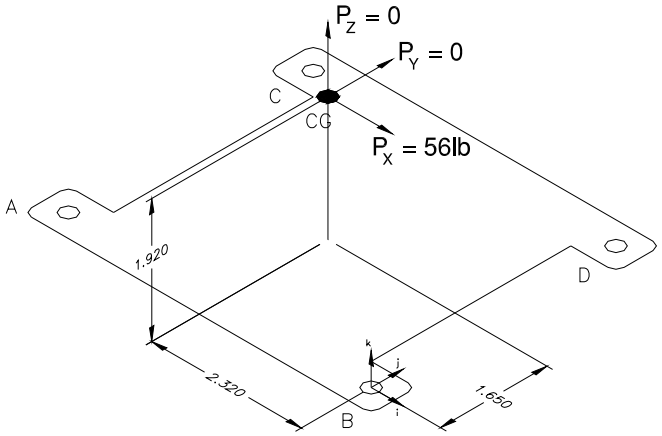
$M_A = -107.52j + 92.4k$
$M_A = 141.8$ in-lb_f

Shearing stress induced by torque is:
$\tau = Mr/J$; where $J = 0.5\pi r^4$

$\tau_1 = Mr/J = (141.8)(.125)/[(0.5)\ (\pi\ )(.125)]^4$
$\tau_1 = 46219.6$ psi $= 46.22$ ksi

$\tau_2 = Mr/J = (141.8)(.0938)/[(0.5)\ (\pi\ )(.0938)]^4$
$\tau_2 = 10938.2$ psi $= 109.4$ ksi

• For the moment about Screw B:



P = 56i + 0j + 0k
n = -2.32i + 1.65j + 1.92k

$$M_B = P \times n = \begin{vmatrix} i & j & k \\ 56 & 0 & 0 \\ -2.32 & 1.65 & 1.92 \end{vmatrix}$$

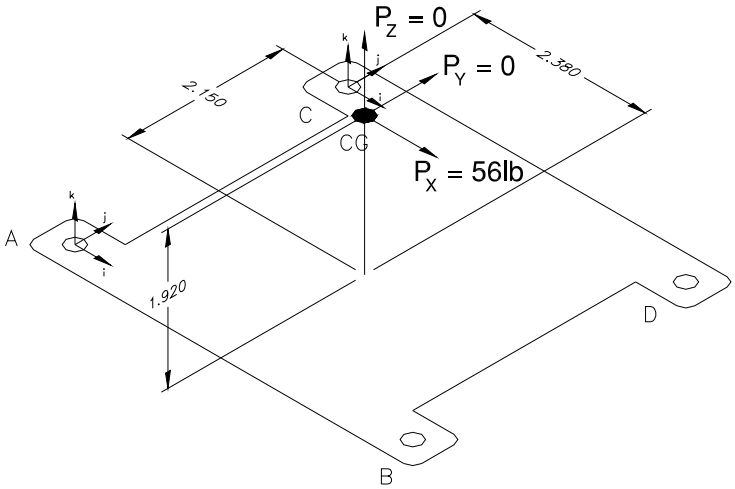
$M_B = -107.52j + 92.4k$
$M_B = 141.8$ in-lb$_f$

Shearing stress induced by torque is:
$\tau = Mr/J$; where $J = 0.5\pi r^4$

$\tau_1 = Mr/J = (141.8)(.125)/[(0.5)\ (\pi\ )(.125)]^4$
$\tau_1 = 46219.6$ psi $= 46.22$ ksi

$\tau_2 = Mr/J = (141.8)(.0938)/[(0.5)\ (\pi\ )(.0938)]^4$
$\tau_2 = 10938.2$ psi $= 109.4$ ksi

- For the moment about Screw C:



$P = 56i + 0j + 0k$
$n = 2.38i – 2.15j + 1.92k$

$$M_C = P \times n = \begin{vmatrix} i & j & k \\ 56 & 0 & 0 \\ 2.38 & -2.15 & 1.92 \end{vmatrix}$$

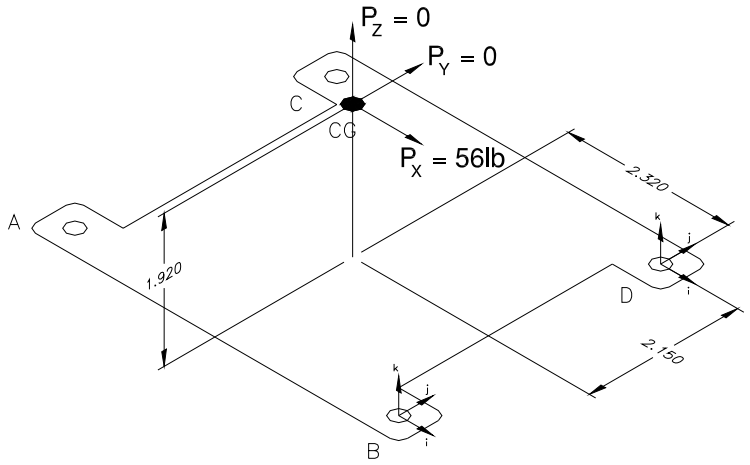
$M_C = -107.52j - 120.4k$
$M_C = 161.4 \text{ in-lb}_f$

Shearing stress induced by torque is:
$\tau = Mr/J$; where $J = 0.5\pi r^4$

$\tau_1 = Mr/J = (161.4)(.125)/[(0.5)\ (\pi\ )(.125)]^4$
$\tau_1 = 52608.2 \text{ psi} = 52.61 \text{ ksi}$

$\tau_2 = Mr/J = (161.4)(.0938)/[(0.5)\ (\pi\ )(.0938)]^4$
$\tau_2 = 124501.6 \text{ psi} = 124.5 \text{ ksi}$

- For the moment about Screw D:



$P = 56i + 0j + 0k$
$n = -2.32i – 2.15j + 1.92k$

$$M_D = P \times n = \begin{vmatrix} i & j & k \\ 56 & 0 & 0 \\ -2.32 & -2.15 & 1.92 \end{vmatrix}$$

$M_D = -107.52j + 120.4k$
$M_D = 161.4 \text{ in-lb}_f$

Shearing stress induced by torque is:
$\tau = Mr/J$; where $J = 0.5\pi r^4$

$\tau_1 = Mr/J = (161.4)(.125)/[(0.5)\ (\pi\ )(.125)]^4$
$\tau_1 = 52608.2$ psi = 52.61 ksi

$\tau_2 = Mr/J = (161.4)(.0938)/[(0.5)\ (\pi\ )(.0938)]^4$
$\tau_2 = 124501.6$ psi = 124.5 ksi

<u>For the Y and Z-direction shake:</u>

Forthcoming