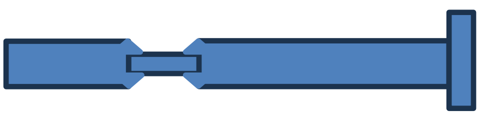
Calibrated Tension Bolt, Version 1.0

By R. G. Sparber

I am lifting bronze frames. The maximum estimated weight per lift point is 150 pounds, which is less than half the rated maximum for any part used in the lift. What I didn't know was whether the threaded hole I would cut into the bronze frame could handle the weight without stripping. A failure could cause injury, so I must be extremely careful.

I plan to use a #7 drill to cut a tap hole. Then tap ¼-20, which should give me a 75% thread engagement. Then I plan to test the threaded hole, but not to the point of tearing out the threads.



My solution was to machine a series of ¼-20 bolts with a necked-in section.

I took care to avoid sharp transitions because they would become stress concentration points. By measuring the diameter of each necked in section, I can roughly calculate its breaking point.

Bottom Line:

$$D = \sqrt{\frac{\text{ultimate load}}{45.6\times 10^3}} \qquad (4)$$

Where D is the necked-down section's diameter in inches, and load is in pounds.

Theory

The total failure point, or ultimate load, equals the material's ultimate tensile strength times its area. With Ultimate Tensile Strength in Pounds per square inch (PSI), the area is in square inches.

The Ultimate Tensile Strength varies with the grade of the bolt. According to Engineering Toolbox[2], it is 74000 PSI. Ecosteel[3] gives the range of 58,000 to 80,000 PSI. I'm using low-grade bolts, so I'll assume 58,000 PSI.

$$\text{ultimate load} = 58{,}000\ \frac{pounds}{in^2} \times area\ in^2 \qquad (1)$$

$$area = pi\ \times \frac{D^2}{4} \qquad (2)$$

Combining (1) and (2,

$$\text{ultimate load} = 45.6 \times 10^3 \times\ D^2 \qquad (3)$$

Where D is in inches, and load is in pounds.

Say I have necked down the bolt to a diameter of 0.1".
From (3) we find that the ultimate load is about 460 pounds[4].

The necked-down section should snap at about 460 pounds.

Conversely,

$$D = \sqrt{\frac{\text{ultimate load}}{45.6\times10^3}} \qquad (4)$$

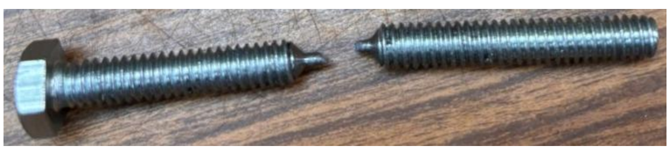
Where D is in inches, and load is in pounds.

[2] https://www.engineeringtoolbox.com/us-bolts-tensile-proof-load-d_2066.html
[3] https://www.econsteel.com/blog/tensile-strength-of-steel
[4] I am assuming an accuracy of 2 places so rounded up to 460 from 456.

Testing

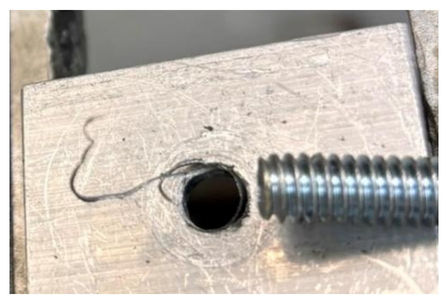
I took a test bolt with a 0.075” diameter necked-down section (260 pounds to break it) and spun a nut to just under the head. Then I added a washer and a thick piece of steel. I threaded the assembly through a 1 1/8 inch socket. I then threaded the test bolt into a rather loose ¼-20 tapped hole. The top nut was spun down until the assembly was snug.

Using a socket wrench to prevent the bolt from turning, I tightened the nut with a box wrench until the bolt snapped.



Notice that the necked-down section broke in the middle, which means that I did not introduce any stress-concentrating corners.

I repeated the test, using an unmodified bolt. I was able to tear out the threads before the bolt broke.



Conclusion

The first test shows that I can pull 260 pounds without damaging the threads. The second test demonstrates that I can pull enough force to tear out the threads. Therefore, 260 pounds is not enough to damage the threads.

I will now use this arrangement on the bronze frames to verify that the threaded holes will support the required weight.

I welcome your comments and questions.

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