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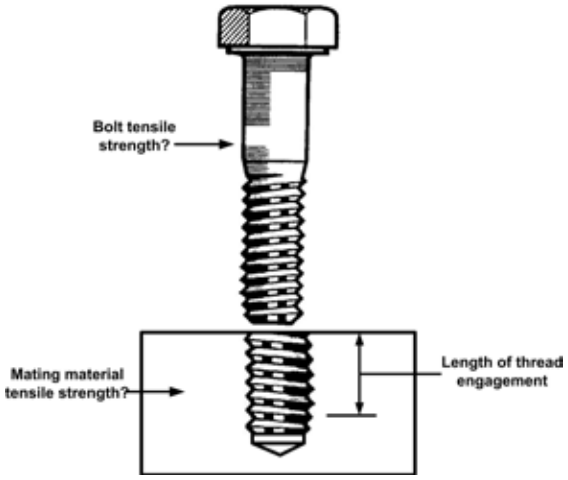
Calculating Thread Strength



An important fundamental of joint design is that, whenever possible, a joint should be designed so that the bolt or screw's breaking is the mode of failure. The reasoning behind this is if there is a product assembly error resulting in a failed joint a broken screw or bolt is obvious where as a stripped bolt or internal thread is not. An obvious broken screw or bolt can be replaced before the end product is put into service. When joint failure is by thread stripping that failure may not become obvious until the end product is put into service resulting in much greater problems and associated cost of repair.

One of the most frequently asked applications questions is, "What length of thread engagement is needed to avoid thread strip-out?" This is relatively easy to determine with a few facts and a little arithmetic.

The facts that are needed are as follows:

1. Thread size
2. Bolt material tensile strength
3. The tensile stress area (A_s)
4. The bolt thread shear area per inch (AS_s)
5. The internal thread shear area per inch (AS_n)
6. The shear strength of the material being tapped (tensile strength X 0.5)

All of this information is in the IFI 7th Edition Inch Standards Book for inch products and in the IFI 3rd Edition Metric Standards Book for metric products. The chart below is an excerpt from the inch book.

Size	Bolt tensile Stress Area sq. in.	Bolt Thread Stripping Areas sq. in. per in. of Engagement	Internal Thread Stripping Areas sq. in. per in. of Engagement
1/4-20 UNC	0.0318	0.368	0.539
5/16-18 UNC	0.0524	0.470	0.682
3/8-16 UNC	0.0775	0.576	0.828
7/16-14 UNC	0.106	0.677	0.981
1/2-13 UNC	0.142	0.779	1.12
9/16-12 UNC	0.182	0.893	1.27
5/8-11 UNC	0.226	0.998	1.42
3/4-10 UNC	0.334	1.21	1.72
7/8-9 UNC	0.462	1.43	2.03
1-8 UNC	0.606	1.66	2.33

Below is a sample calculation for an inch fastener application:

1. Thread size: ¾-10
2. Bolt material tensile strength in PSI: SAE Grade 5 – 120,000 PSI
3. The tensile stress area per inch, A_s: 0.334 sq. in.
4. The bolt thread shear area per inch, AS_s: 1.21 sq. in.
5. The internal thread shear area per inch, AS_n: 1.72 sq. in.
6. The tensile strength of the material being tapped: 60,000 PSI
   Note: The shear strength of steel is 50% of its tensile strength.

Steps	Characteristic	Formula
1	¾-10 Grade 5 bolt tensile strength (pounds)	= A_s X bolt material tensile strength = 0.334 X 120,000 PSI = **40,080 pounds**
2	Bolt thread shear strength per inch	= AS_s X bolt shear strength = 1.21 X 60,000 = **72,600 pounds per inch**
3	Length of engagement needed to avoid bolt thread stripping	= bolt tensile strength ÷ bolt thread shear strength per inch = 40,080 ÷ 72,600 **= 0.552 inches**
4	Internal thread shear strength per inch	= AS_n X Internal thread shear strength = 1.72 X 30,000 PSI = **51,600 pounds per inch**
5	Length of engagement needed to avoid internal thread stripping	= bolt tensile strength ÷ internal thread shear strength per inch = 40,080 ÷ 51, 600 **= 0.777 inches**
6	**Conclusion: What length of engagement will assure the mode of failure in this joint will NOT be thread stripping?**	**Answer: 0.777 inches.** To assure that thread stripping is NOT the failure mode select the longer of the two thread stripping calculations. In this case it was the length of engagement for the internal thread.

The conclusion of this analysis should always be to establish a length of thread engagement in the application that is at least the length of the longer of the two thread shear area calculations. In no case should a length of engagement be longer than 1.5 times the diameter of the thread be used as a length of engagement. When a length of thread engagement longer than 1.5 D is used thread galling due to normal thread lead errors can occur. When this occurs the thread galling prohibits achieving proper clamping in the joint.

Once a length of engagement is achieved that assures that bolt breaking will be the mode of failure in the joint additional length of engagement does NOT enhance joint safety or reliability.

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