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## **FINE THREAD Vs. COARSE THREAD** ***WHICH ONE IS THE BETTER THREAD?***

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### **Introduction:**

In general, most bolt sizes are available in coarse and fine thread options. For example, ISO Metric Coarse Pitch Series (Metric Screw Threads for Fasteners -AS1275-1985) and ISO Metric Fine Pitch Series (General Purpose Metric Screw Threads – AS1721-1985) specify the options for metric threads. Similarly, Unified National Coarse Thread (UNC) and Unified National Fine Thread (UNF) are specified in AS3635-1990, Unified Screw Threads standard.

Which type of thread is best for a particular application is a common question. This paper analyzes the various parameters that need to be considered and their effects on the performance of a generic bolted joint.

### **Load Carrying Capacity:**

Typically, bolts are designed for carrying tensile loads (in tension joints) and shear loads. In a tensile bolted joint the most critical parameter is the applied pre-tension load [1]. In such joints, a fastener that can provide the maximum tensile load is preferable. Similarly, if the bolt is subject to shear loads the effective shear area at the shearing planes needs to be maximized. In general, it is assumed that the failure will occur in the bolt (which is preferable and the design criterion for failure).

In case of metric threads, the thread geometry for fine and coarse threads is defined in a parametric form using the *pitch* as the determining parameter. As such, the thread form of fine thread will be identical to the thread form of coarse thread in its gross geometric features.

### ***First Order Analysis***

If we apply a first order approximation (assuming total load is evenly distributed over the entire engagement length) on the load carrying capacity of a bolt, we find it is directly related to the shank diameter. Furthermore, shear failure of the threads should not occur when the bolt is engaged appropriately with the corresponding nut. This means that the threads with larger effective shear areas will be better. The thread profile for ISO Metric thread depends on the pitch of the thread, although the general form is the same. If we calculate the effective tensile stress area of the bolt it can be seen that this area drops as the pitch is increased.

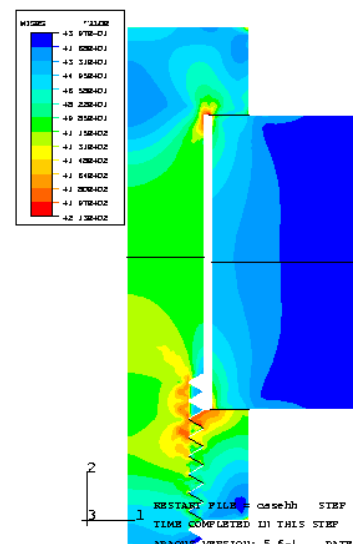
For example, a M10x1.0 bolt has an effective tensile stress area of 61mm<sup>2</sup> while a M10x1.5 bolt will only have 55mm<sup>2</sup>. As such, the failure load of the bolt should be approximately 11% larger for the finer pitch bolt. Similarly if we calculate the thread shear area along the pitch-line per millimeter of the bolt length M10x1.0 bolt results 4.14mm<sup>2</sup> while M10x1.5 results 4.02mm<sup>2</sup>. This gives approximately 3% larger thread shear area for the finer threaded bolt. This effectively reduces the minimum engagement length requirement by approximately the same percentage. In essence, the above discussion shows that fine threads are slightly better than coarse threads in terms of load carrying capacity.

However, some schools of thought prescribe that there is no significant difference between fine and coarse threads in load carrying capacity; and that coarse threads shall be used at all times because they provide adequate strength and great advantages over fine threads. Coarse threads are less liable to become cross-threaded, they start more easily particularly in awkward positions, and require less time to tighten. On the other hand, fine threads have been found to be more suitable in cases where fine adjustment is required.

### ***Higher Order Analysis***

If a higher order analysis including the effect of helix angle of the thread and the resulting force resolution is considered, it becomes evident that the higher helix angle inherent to coarse thread will increase the local forces and stresses on the threads [2]. This could lead to bearing failure on the threads and hence galling.

Ajax Fasteners has conducted a comprehensive Finite Element Analysis (FEA) on a generic bolted joint. This analysis revealed even more interesting facts regarding the micro level distribution of stresses [3]. In summary, it was found that the threads are not equally loaded and at typical applied loads (65% Proof Load) the first engaged thread (closest to the head) will carry up to 33% of the applied load. The ensuing threads will carry ≈ 27%, 20%, 12% and 8% respectively. Any extra threads engaged do not carry any load. As can be expected, the above distribution is affected by the bolt tension and the thread geometry and material properties of both the bolt and the nut. In general, considering the stress-strain relationship for steel, as the load is increased further



the first thread will reach yield and plastically deform while carrying the maximum possible load on the first thread and distributing the remaining load over a few more threads. With further increasing load, the above process will continue over the full engaged-thread length until all the threads yield and subsequently fail. However, a bolted joint should be designed to always force the failure in the bolt shank and not in the thread and therefore, if designed properly, this type of thread stripping should not occur.

The above findings also suggest that a larger number of engaged threads (fine pitch) will improve the performance of the joint as the stresses are distributed over a larger area; hence reducing the resulting local stress concentrations.

### ***Experimental Results***

When a bolt engaged with an appropriate nut is stretched to failure, an effective stress area of the thread for the bolt can be defined, based on the failure load and the material properties. When comparing the experimentally determined effective stress areas of the threads, it is always found that the fine thread will have a larger effective stress area than the coarse thread as predicted in theory. This result compounds all of the higher order effects discussed above. Typically, fine threads will have a 6 – 10% increase in effective stress area of thread in comparison to coarse threads [4].

### **Vibration Loosening**

Ajax Fasteners has conducted a comprehensive research program on vibration loosening. It was found that - in most situations - vibration loosening occurs when the bolts are not tightened to the minimum specified tensile load ( $\approx 65\%$  proof load). In the analysis of vibration loosening it was found that the thread helix angle plays a relatively important role. The larger the helix angle the higher the tendency for loosening. Furthermore, fine threaded bolts will have more threads yielding while tightening to an adequate pre-load. The resulting plastic deformation on the threads acts as a locking mechanism on the bolted joint. When considering these facts, it can also be concluded that fine threads are less susceptible to vibration loosening.

### **Conclusion:**

The suitability of a coarse or fine thread for a particular application has to be determined on a case by case basis. In general, both coarse and fine threads are capable of providing sufficient strength for most applications. Coarse threads are easier to assemble and need less care; hence they are more commonly used. Fine threads will, in general, have higher load carrying capacities and higher resistance to vibration loosening. Fine threads are less tolerant to damage and are easily cross-threaded and therefore require careful assembly.

### **References:**

1. S. Fernando, "An Engineering Insight to the Fundamental Behaviour of Tensile Bolted Joints", Journal of the Australian Institute of Steel Construction, Vol. 35, No 1, March 2001.
2. S. Fernando, "An Engineering Insight to the Fundamentals of Screwed Sheet Fastening to Resist Cyclic Loading", 9<sup>th</sup> Wind Engineering WorkShop, James Cook University, Townsville, July 2001.

3. S. Fernando, D. Kershaw, "Threaded Fasteners in the New Millenium", Materials Australia, Vol 30, No 6, November/December 1998.
4. Ajax Fasteners Fastener Handbook, Bolt Products, 1999.

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Ajax Fastener Innovations (AFI) offers a consulting service to assist in the design of bolted joints in specific applications. AFI has the experience; test equipment, analysis methods, and analysis tools developed over many years, to provide our customers with a greater level of confidence in the design of critical joints. Furthermore, AFI is dedicated to developing fastening solutions that cater for the specific needs of industry.

If you need any further assistance please contact us.