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Static strength of screwed fasteners

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THE PREPARATION OF THIS DATA ITEM

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STATIC STRENGTH OF SCREWED FASTENERS

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STATIC STRENGTH OF SCREWED FASTENERS

1. DEFINITIONS AND NOTATION

bolt	externally threaded solid rod		
nut	internally threaded component with external diameter at least 1.5 times internal diameter		
A_c	core area of bolt	m^2	in^2
A_{min}	area of smallest cross-section of bolt	m^2	in^2
A_{sb}	shear area of bolt thread (see Appendix A)	m^2	in^2
A_{sn}	shear area of nut thread (see Appendix A)	m^2	in^2
D	nominal diameter of thread	m	in
f_{tb}	tensile strength of bolt material	N/m^2	lbf/in^2
f_{tn}	tensile strength of nut material	N/m^2	lbf/in^2
L_e	axial length of thread engagement	m	in
m	number of unengaged bolt threads on loaded side of nut		
P	applied axial tensile load	N	lbf
P_{sb}	median value* of axial stripping load of bolt thread	N	lbf
P_{sn}	median value* of axial stripping load of nut thread	N	lbf
P_{tb}	median value* of tensile failing load of bolt	N	lbf
p	pitch of thread	m	in

Both SI and British units are quoted but any coherent system of units may be used.

* The median value is that value exceeded in half the tests.

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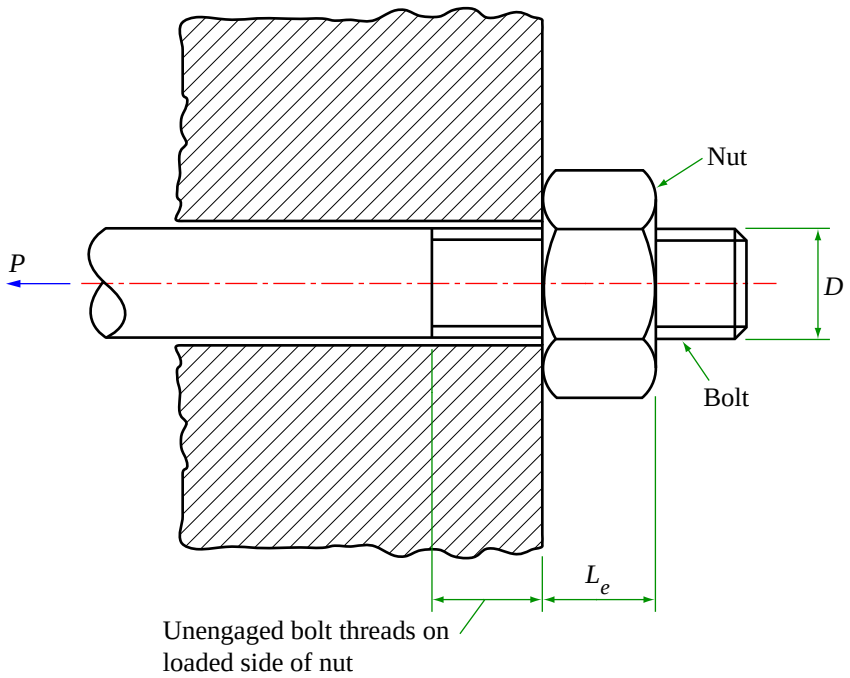
2. INTRODUCTION

Specifications are available for standard steel screw threads which give information on the minimum and maximum loads for safe usage. These specifications are based upon tests carried out on standard threads, and most design is carried out using such values. Manufacturers and suppliers will usually supply test certification on request stating the recommended load values to be used in conjunction with a specified thread. This Data Item gives some background on the actual failure loads of threads, and can be used to calculate safe usage loads for thread forms not covered by standards or specifications.

An analysis of about 1300 laboratory tensile tests on axially loaded screwed fasteners has been made. Data on the tensile and stripping strengths of such fasteners are presented in terms of the probability of failure.

The main features of the geometry and loading considered are shown in Sketch 2.1



Sketch 2.1

Information on the fatigue strength of screwed fasteners may be located by reference to the Engineering Sciences Data Index.

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3. SUMMARY STATEMENT OF EXPERIMENTAL VARIABLES

3.1 Data on Tensile Fracture of Core

D	:	0.138 to 1.000 in (4 to 25mm)
f_{tb}	:	64 000 to 209 000 lbf/in^2 (440 to 1440 MN/m^2)
p/D	:	0.083 to 0.20
Thread series	:	UNF, UNC, ISO metric

All bolts were steel; none was surface hardened.

3.2 Data on Thread Stripping

D	:	0.375 to 1.04 in (10 to 26 mm)
f_{tb} or f_{tn}	:	62 000 to 161 000 lbf/in^2 (430 to 1110 MN/m^2)
L_e/D	:	0.133 to 0.875
Thread series	:	UNF, UNC, BSW, BSP, ISO metric

All results on which Table 5.1 is based were obtained from steel bolts or nuts.

4. TENSILE FRACTURE OF CORE

In Figure 1, $P_{tb}/f_{tb}A_c$ is plotted against p/D for a range of values of m. The proportion of P_{tb} associated with other standard failure probabilities is quoted. The range of p/D covered by various screw thread series down to 0.25 in (6 mm) diameter is indicated.

The curves are based on a correlation of some 1100 test results. Two thirds of the data were quoted in the form of mean values, so the probability values are based on only 340 results.

The data from which Figure 1 was derived were obtained from tests on ductile steel bolts with nominal tensile strengths up to 209 000 lbf/in^2 (1440 MN/m^2). The curves may also be expected to apply to other ductile materials, for example, titanium alloys with $f_{tb} \leq 100\ 000$ lbf/in^2 or 700 MN/m^2. The proportion of P_{tb} associated with a given failure probability is likely to vary somewhat with material.

Figure 1 applies strictly to threads of Unified or ISO metric form. For Whitworth threads the value of $P_{tb}/f_{tb}A_c$ is expected to be slightly higher than indicated; for the special large radius (UNJ) thread form it is slightly lower than indicated.

The curves apply only to bolts that failed in the threaded portion. Tensile failure of a bolt with a waisted shank or grooved thread run-out may occur at a load less than that indicated by Figure 1 when

$$P = f_{tb}A_{min}. \tag{4.1}$$

For ductile bolts that are neither waisted nor grooved, static tensile failure may be entirely avoided by ensuring that

$$P < f_{tb}A_c, \tag{4.2}$$

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