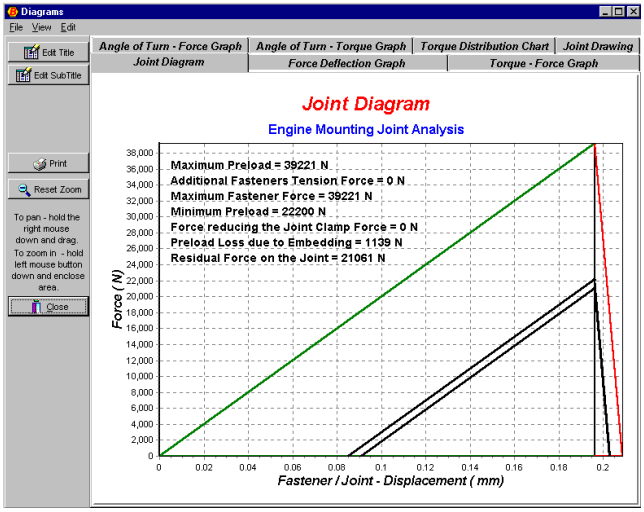
BOLTCALC®

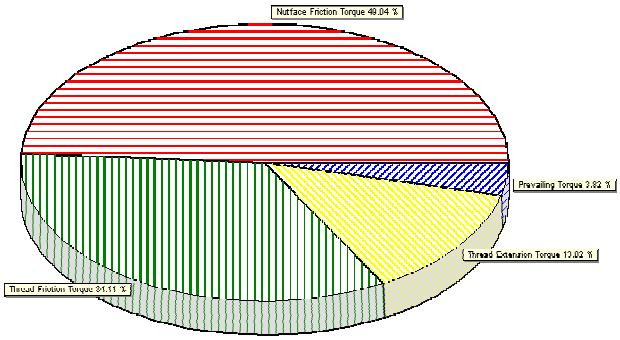
Analysis of concentrically and shear loaded bolted joints.

BOLTCALC is a specialised computer program for use under the Microsoft Windows operating systems (Windows XP, Vista, Windows 7) and will determine whether or not a bolted joint will successfully sustain the forces acting it. If the joint is being designed it can estimate the size of bolt required for the application. Once the bolt size has been estimated, or details of an existing joint have been entered, detailed calculations can be performed.

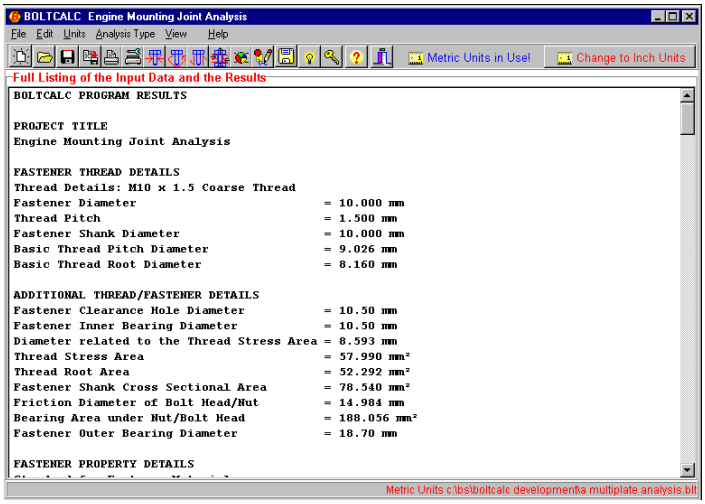


If a joint is being designed the program can estimate the size of bolt required for the application. Once the bolt size has been estimated, or details of an existing joint have been entered, detailed calculations can be performed. The calculations will determine whether or not the bolt will fail by:

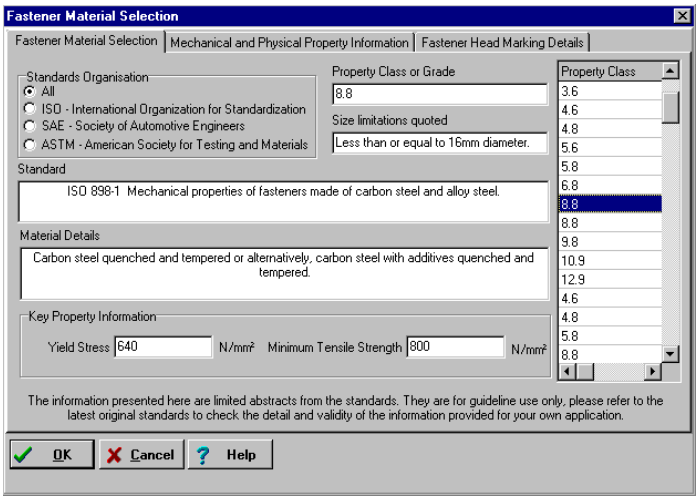
- the joint not being clamped together sufficiently,
- direct overload of the bolt,
- fatigue failure,
- excessive bearing stress,
- either the internal or external thread shearing.



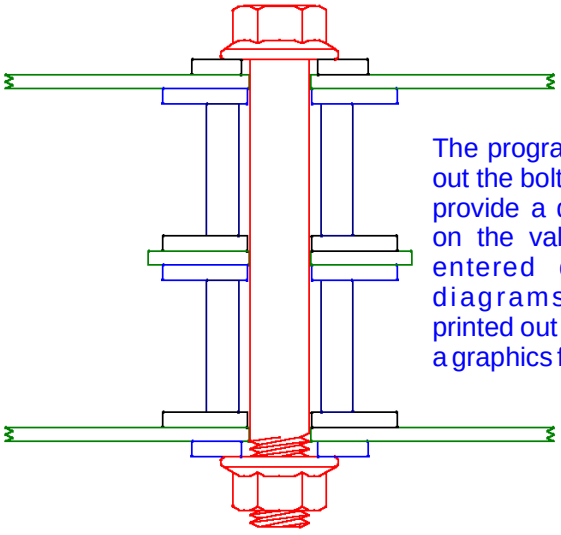
A range of output options are available for the results, including the production of a joint diagram, torque distribution diagrams, torque/angle of turn graphs and force-deflection graphs.



The program is designed for easy of use. For example, selecting a particular strength grade of bolt will allow the program to refer to all the material's relevant properties without calling upon the user to type them into the program.



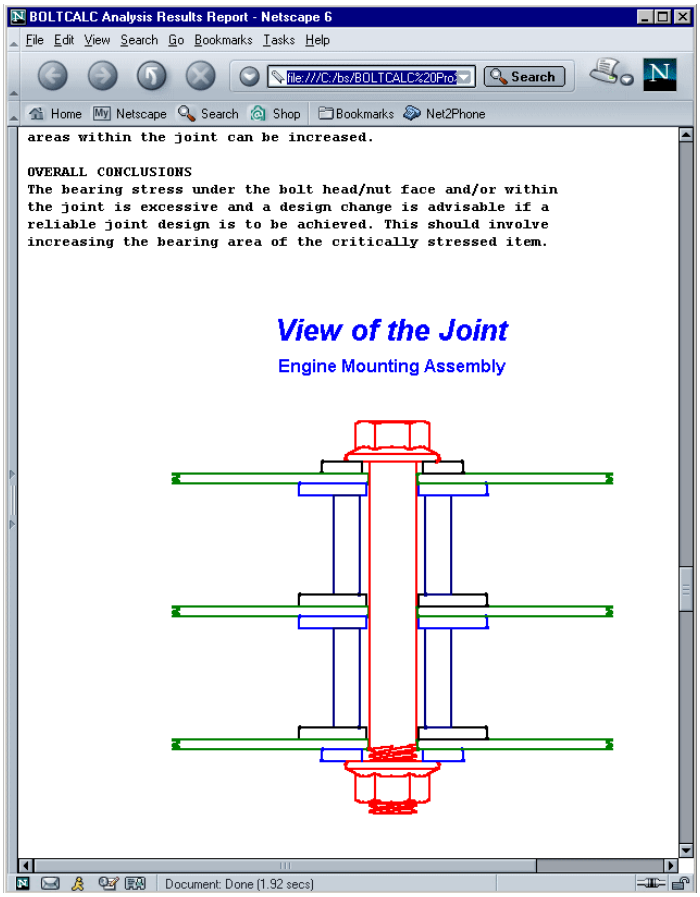
The program accesses extensive databases on thread sizes, bolt material properties, thread and head friction coefficients and torque tables. The program works in both metric and inch based units and associated thread and bolt material data.

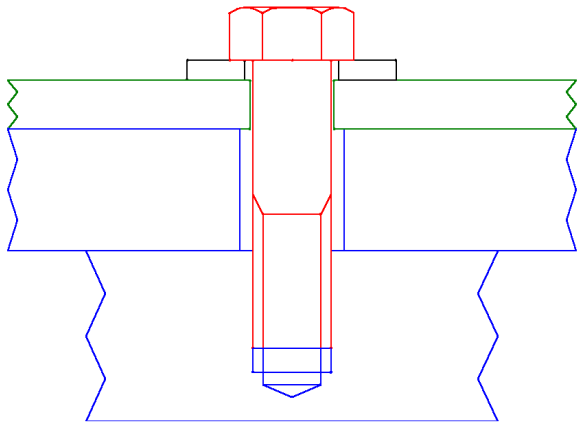


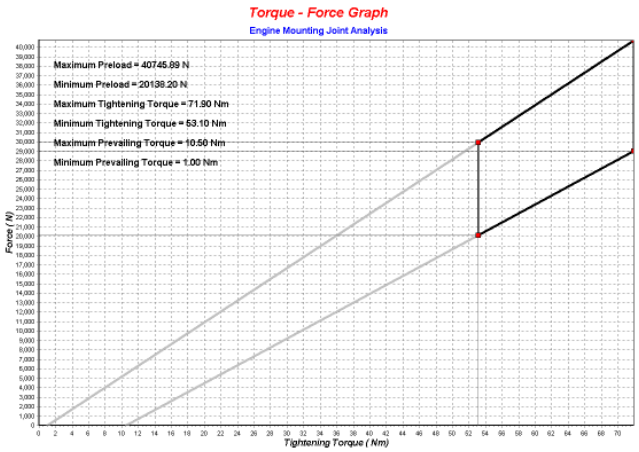
The program will draw out the bolt and joint to provide a quick check on the validity of the entered data. The diagrams can be printed out or saved as a graphics file.

BOLT CALC problems ulated

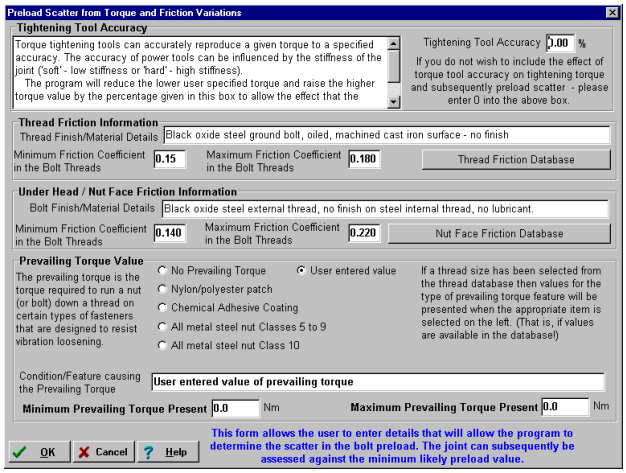
The results and graphs can be viewed and printed from within the program or alternatively all the results can be output as html and image files and then automatically loaded into a web browser as shown below.







The program includes extensive databases of friction values (anticipated maximum and minimum values derived from test results). The program can use this data to establish the likely scatter in the bolt preload to allow the analysis to be completed on the basis of minimum preload values rather than the mean or maximum.



Besides a full joint analysis, the program will complete separately:

- A torque analysis that will determine the what the appropriate torque value to apply to a fastener, or the preload if the torque value as already been determined.
- A thread stripping analysis that will establish if thread stripping is likely.

BOLT SCIENCE

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There is a demo program available for BOLTCALC from our website.

Bolt Science provides analytical solutions to bolting problems.

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Analysis of concentrically and shear loaded bolted joints.

Questions answered by BOLTCALC

The program addresses a number of questions that an engineer typically requires to be answered when dealing with bolted joints, such as:

- What size and strength of bolt should I use?
- Is the bolt likely to fail due to fatigue?
- I have tapped holes in my assembly - are the threads likely to strip?
- Will the bolt be overloaded?
- Do I need to use washers or flanged fasteners in my application?
- I need to include elongated holes in the joint for assembly reasons - will these affect joint reliability?
- My joint is made up of different materials - what effect will this have on the joint's performance?

The program assists the engineer in providing answers to these questions by checking the bolt stresses and forces acting and whether or not a particular failure mode is likely. The failure modes that the program checks for are presented below.

The **BOLTCALC** program performs checks to ensure that the bolt, or the joint, will not fail due to a number of failure modes. Specifically, factors of safety are presented for five possible failure modes:

1. Failure of the bolt to provide sufficient clamp force.

The main factor as to whether a bolted joint will sustain the applied forces is will the bolts generate sufficient clamp force? For any application there is a minimum clamping force required to prevent joint failure. The clamping force is required to prevent joint movement being caused as a result of axial and/or shear forces. Both axial and shear forces, acting individually, or simultaneously, can be taken into account, together with any residual clamp force that may be required to maintain a functional requirement such as gasket sealing. In many instances, when a gap in the joint or slippage occurs, then failure by the bolt loosening or fatigue will occur. When fatigue failure occurs, the cause is frequently insufficient preload rather than poor fatigue strength.

2. The bolt being overloaded by the applied force.

If a very high axial force is applied to a joint there is the possibility that the bolt will sustain additional loading that will cause its yield strength to be exceeded. If this does occur then either the bolt will fail due to direct tensile failure, or, when the load is removed, will sustain a plastic deformation that will result in preload loss that could cause the bolt to loosen. The program checks for this possible failure mode and determines a safety factor. For the majority of joints, failure by direct overloading is unlikely because the bolt usually sustains only a small proportion of any force applied to the joint.

3. Fatigue failure of the bolt.

All materials have a tendency to fail under repeated loading at a stress level considerably less than the static strength of the material. This characteristic of materials is known as fatigue and it is a common cause of failure in many products, including bolts. The program will calculate the alternating stress in the thread of the bolt, based upon the forces entered and the characteristics of the joint. The program will calculate the fatigue strength of the bolt material, based upon the user's selection as to whether the bolt thread was rolled or machine cut. The program uses lower bound, empirically derived values for the fatigue endurance strength. If the user has specific information on the fatigue endurance strength of the bolt being analysed, then this can be used in preference to the program value.

4. Excessive bearing pressure.

If the bearing pressure under the nut face exceeds the compressive yield strength of the joint material, plastic deformation will occur. The preload loss from embedding determined by the program, assumes that the compressive yield strength is not exceeded. If it is, then such preload loss can increase uncontrollably. The program checks that the bearing pressure is within acceptable limits and if it is not, recommends a number of design alternatives.

5. Thread Stripping Analysis

Thread stripping is a shear failure of an internal or external thread that results when the strength of the threaded material is exceeded by the applied forces acting on the thread.

Thread stripping can be a problem in many designs where tapped holes are required in low tensile material. In general terms thread stripping of both the internal and external threads must be avoided if a reliable design is to be achieved. If the bolt breaks on tightening, it is obvious that a replacement is required. Thread stripping tends to be gradual in nature and it may go unnoticed at the time of assembly. It starts at the first engaged thread, deformations causing this thread to carry the highest load; and successively shears off subsequent threads. This may take a number of hours to complete and so the product may appear fine at the time of assembly. The risk is therefore present that threads that are partially failed, and hence defective, may enter service. This may have disastrous consequences on product reliability. The program checks for thread stripping of the internal and external threads.

The BOLTCALC Databases

The program includes a number of databases. The purpose of these databases is to assist the user in entering standard values into the program. Details of these databases are given below:

Metric Thread Database

Contains the principal metric thread sizes from M1 to M200 (84 sizes) including metric coarse and fine threads. Contains details of the principal thread head and hole dimensions, prevailing torque values for various grades of fasteners.

Inch Thread Database

Contains the principal inch thread sizes from #0 to 4 inches (73 sizes) covering UNC and UNF and constant pitch series threads. Contains details of the principal thread head and hole dimensions, prevailing torque values for various grades of fasteners.

Metric Bolt Material Database

Contains the major bolt material specifications covering ISO, SAE and ASTM standards (112 records). Includes steel, alloy steel, stainless steel and non-ferrous metals. Details of bolt head marking requirements specified in the relevant standard is also included.

Inch Bolt Material Database

Contains the major bolt material specifications covering SAE and ASTM standards (160 records). Includes steel, alloy steel, stainless steel and non-ferrous metals. Details of bolt head marking requirements specified in the relevant standard is also included.

Thread Friction Coefficient Database

Contains 123 records of thread friction coefficient values for various finish and material conditions. Minimum, mean and maximum coefficients are provided together with details of the source of the information (publication, report or test report reference).

Head Friction Coefficient Database

Contains 157 records of head friction coefficient values for various finish and material conditions. Minimum, mean and maximum coefficients are provided together with details of the source of the information (publication, report or test report reference).

Metric and Inch Torque Range Databases

Includes records to allow a standard range of torque values (minimum/maximum) to be selected to match with manufacturing requirements to prevent a profusion of torque values being specified.

The databases are used in a read only manner by **BOLTCALC** but can be edited to allow values to be added, deleted or changed by Bolt Science's **DBEditor** program.