

# Why bolted joints fail

The problem of bolted joint loosening has been a concern since the first screws were used in the 15th century. The mechanism of loosening is best illustrated by imagining the bolt thread unwound from the shank. It is, in effect, a ramp. The mating thread is a small block placed on this ramp. The forces that hold the joint together are friction and the compression of the material between the nut and bolt members (clamp load). If the outside forces acting on the joint exceed the clamp load, the parts move sideways (dilation).

As the block is pushed sideways across the ramp, it will also move downhill. This is loosening. The higher the preload (clamping force) the faster the block moves downhill if the clamp load is exceeded. Repeated sideways movement (vibration) comes in several frequencies; very small, rapid repeated impacts cause frequent slow unwinding (fretting loosening) while sharp, hard jolts cause faster step-like loosening.

Adequate preload (clamp load which exceeds anticipated service loads), will prevent loosening if it is possible to predict the forces acting on the joint.

Many times the loading on real world joints is not calculable. Service loads that are greater than the clamping load have been known to completely loosen a joint in under a dozen sharp shocks.

The sideways movement does not always come from external shaking of the joint. Significant sliding can be caused by thermal expansion and contraction of the bolted joint (i.e., engine attachments). Bending of joined components also causes transverse sliding and loosening. Once the joint is loosened and the clamp load is, for all practical purposes, lost another attachment failure mode can occur. This is fatigue failure. Fatigue is the constant bending and unbending of the bolted member like a paper clip that is bent until it breaks. Just like the paper clip which could not be pulled apart in our bare hands, it breaks at very very low strength levels in fatigue. Proper clamp load prevents this bending, loose fasteners do not.

