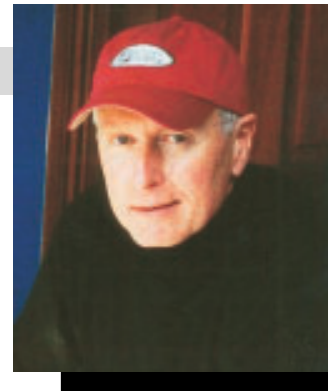


About the Author/WAYNE WALLACE

Wayne Wallace is the president of Applied Bolting Technology Products. The company provides bolting consulting services and manufactures direct tension indicating washers from its base in Rockingham, Vermont. Wallace is a member of the Research Council on Structural Connections, owner of several patents, and author of numerous papers on the practical aspects of quality assurance in structural bolting. He can be reached by phone at 800-552-1999, by fax at 802-460-3104, or e-mail at wwallace@sover.net.



You Can't Tension All Bolts

Engineers often ask distributors to supply heavy hex bolts and nuts, and sometimes distributors suggest some other type of bolt, not realizing that there are a lot of important differences.

For instance, on a recent project in the Middle East, the constructor specified ASTM A325 (heavy hex) bolts and their related ASTM A563 nuts. The steel fabricator/erector offered to supply the bolts they usually used, DIN 931 Grade 8.8, and the question arose: Why not use the DIN 931 bolts? They're about the same strength as A325, are coarse threaded, and come with their associated nuts made to DIN 934 property class 8.

The answer, simply stated, is that the heavy hex form bolt, with wider across-flats head, and with nuts that are deeper and with identical across-flats dimension, **are intended to be tensioned**, while the DIN 931/934 set is **not intended to be tensioned**.

What is meant by this statement: "...intended or not intended to be tensioned...?" Simply put, bolts like A325 are intended to be tensioned to proof load or above proof load. That is, to about yield load or above, and they invariably fail by bolt breakage, not thread stripping. Have a look at Figure 1, showing the type of bolt



Figure 1: Heavy Hex Bolt Breakage

breakage typical in heavy hex bolts. If the bolt fractures during installation, it must be replaced.

Conversely, bolts like DIN 931, if tensioned to proof load or above, will fail by stripping of the bolt or nut threads. Stripped threads are shown in Figure 2. If tightened at all, the DIN 931 bolts are intended to be tightened to *no more* than 70% of proof load, so they don't strip. Stripping of threads is a type of bolt failure that all structural designers (at least, all designers in North America) want to avoid, because if they strip during tightening it will not be noticed. The structure is likely therefore to have an unknown number of stripped bolts in it, and the connection resistance to service loads will suffer.



Figure 2: Stripped Threads

To a steelwork designer working to the North American design codes governing bolted connection strength for "pre-tensioned" connections, which are required for connections resisting reversing loads, earthquake loads, wind loads, supporting equipment, etc., "pre-tensioned" bolts are mandatory. You just can't get the same connection performance with partially tightened bolts.

Figure 3 shows various M20 bolts:

- ASTM A325/A563 - Heavy Hex form, wide head, deep nut, *can be tensioned*.
- BS 4395 - Heavy Hex form, called "High Strength Friction Grip" by the British, wide head, deep nut, slightly longer thread, *can be tensioned*.
- BS 3692 - Smaller head, shallow nut, will strip at proof load.

- DIN 933 - Smaller head, shallow nut, fully threaded, will strip at proof load, called the “German setscrew.” Same as DIN 931 except 931 has short thread.

- BS 4190 - Smaller head, shallow nut, non-precision bolt, wide tolerance bolt, will strip at proof load, very short thread.

- DIN 6914 bolt, DIN 6915 nut - It's hard to see it here, but the 6914 bolt has a wide (heavy) head, but its associated 6915 nut is shallow, and will strip at proof. It's sort of a hybrid heavy hex bolt but with a shallow nut, and can be installed (carefully) to a tension about half or two-thirds of the way to proof in major structures.

Here's a list of bolt specifications that can and cannot be tensioned.

Can Be Tensioned

- ASTM A325, A490 (Imperial or Metric)
- BS 4395
- JIS B1186 (eg Grade F10)
- AU 1252

Cannot Be Tensioned

- BS 3692
- DIN 931, 933
- DIN 6914/15
- BS 4190
- JIS G4105



Figure 3: Only two can be tensioned