

# **INSTRUCTION MANUAL**

**For**

## **High Strength Friction Grip Bolting**



***Cooper & Turner Limited***

CONSTRUCTION . BRIDGE . TUNNEL . RAIL . WIND ENERGY . FASTENERS

# **HIGH STRENGTH FRICTION GRIP BOLTING**

## **Introduction**

High Strength Friction Grip Bolting is well established as an economic and efficient method of joining structural steel. The procedure is simple, but it is important that the friction grip principle is fully understood.

This handbook is for Engineers, Supervisors and Inspectors, so that they may be certain that the joints have been correctly tightened to the pre-loads specified in the design standards.

Adequate instruction must be given to the erection staff, because it is important that they appreciate the difference between building with ordinary black bolts and the High Strength Friction Grip bolt. Erection staff are often to be found using inadequate tools and methods, making it impossible to obtain correct bolt tension.

### **Cooper & Turner are specialists in friction grip bolting**

Offering full technical backing that includes:

#### Services

Visiting consultants  
On-site technical advice  
Suitable tool recommendation  
Commenting on specifications  
Training operatives

#### Visual Aids

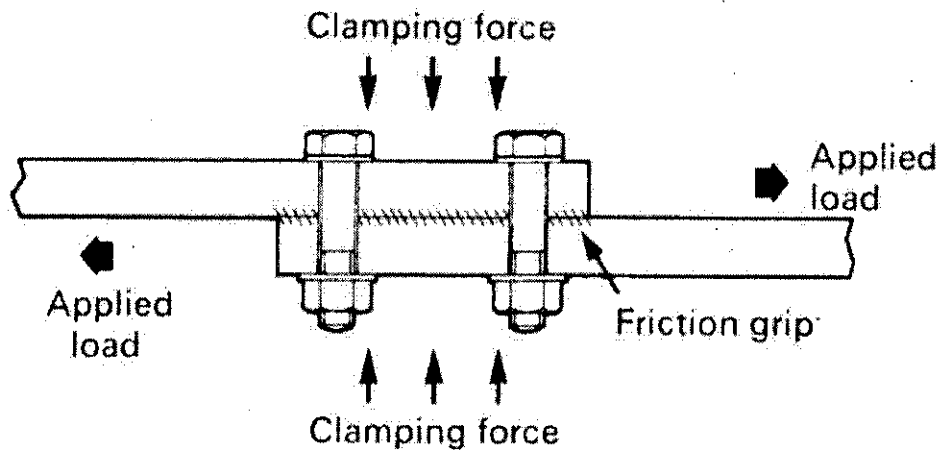
Wall charts for site cabins  
Technical reports  
Literature for erection staff and designers

## HIGH STRENGTH FRICTION GRIP BOLTING

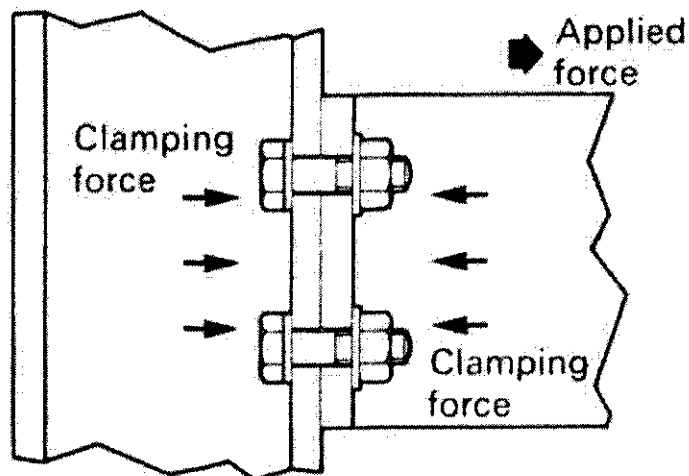
### The Theory

The friction grip principle depends on tightening each High Strength Friction Grip Bolt to a minimum shank tension, so that the specified clamping force on the components being joined may be induced.

This enables the applied load to be carried by friction between the joint faces rather than relying on the shear strength of the bolts that would fail to make use of the friction grip principle.



Even when the applied load is in the direction of the bolt axis, tightening to minimum shank tension is still required. The compression induced in the joining plies by the clamping force prevents the plies separating and thus there is very little or no increase in bolt tension, so long as the applied load is less than the bolt pre-load.



## The Method

From the foregoing it will be appreciated that the security of the friction grip joint depends on the correct tightening of the bolts.

There are three recognized methods of tightening bolts; torque control, part turn or turn of nut, and direct tension measurement.

The torque method requires the use of a calibrated torque wrench or a torque cut-out pneumatic power wrench designed to give a torque measurement.

It must be appreciated that torque can never do more than measure resistance to turning.

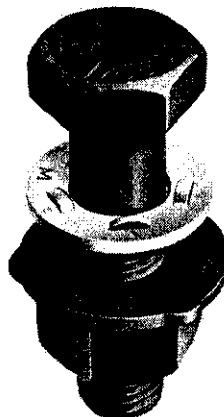
Because of varying conditions of nut and bolt threads, the relationship between torque and the tension induced is dependent on those particular conditions.

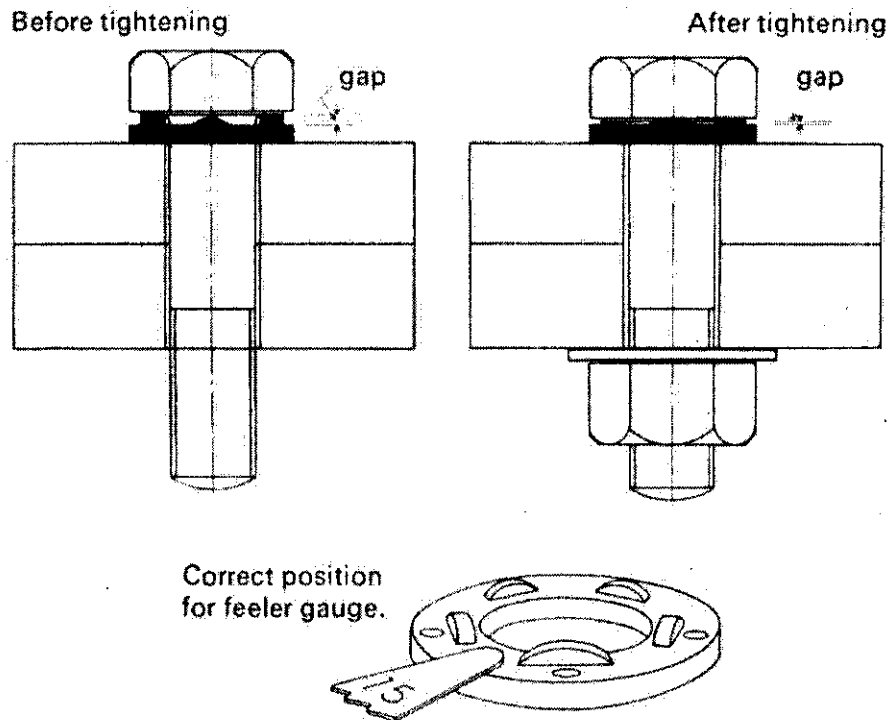
When the threads are dry, dirty, damaged or lacking in lubrication, the friction will be high and, at a given torque setting, the bolt tension will be low. If the threads are well lubricated and free running, the tension induced in a bolt at a similar torque setting will be high. A scatter of  $\pm 40\%$  can readily be obtained by experimenting with bolts in different conditions, using a pre-set torque wrench and a load meter.

The part turn method - to overcome the concern caused by these factors, the second method, known as the 'part turn' or 'turn of nut' system was devised. The principle behind this system is to tighten the bolts into or approaching yield by first snug tightening the bolt and then applying an additional part turn, the amount depending on the grip length of the bolt. This method needs a great deal of operator reliability and supervision. It can only be inspected by close observation during the tightening or by reverting to the already suspect accuracy of the calibrated torque wrench method. It should be noted that the British Standard for the use of higher grades states that the part-turn method is not permitted.

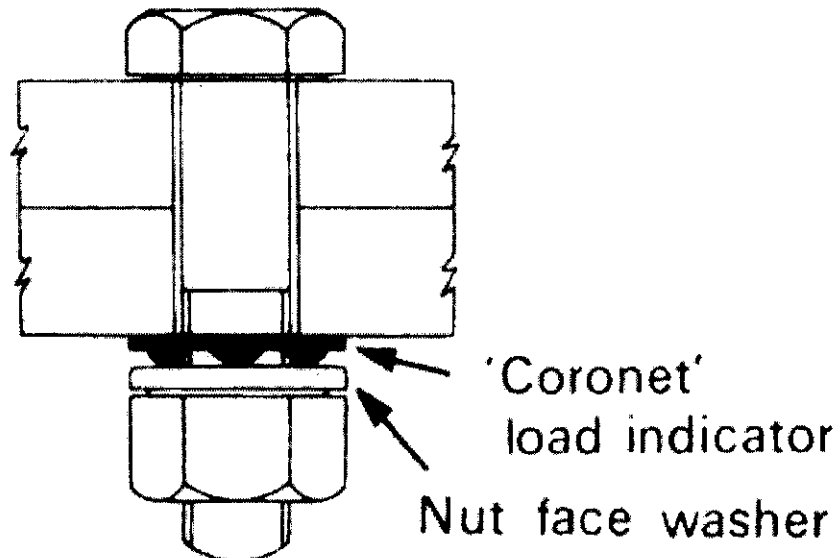
The direct tension method - This method is designed to give a direct indication on the load induced along the axis of the bolt. A load indicating device is fitted into the grip of the bolt assembly, so that the unpredictability of the torque measurement is eliminated. The Standards specify tension not torque.

The 'Coronet' load indicator is a direct tension measuring device comprising a specially hardened washer with protrusions on one face. As the bolt is tightened, the protrusions are flattened and the gap between the load indicator face and the bolt head is reduced. The gap is measured by a feeler gauge and, at the specified gap given in Table 1, the shank tension will not be less than the minimum load specified in the appropriate standard.

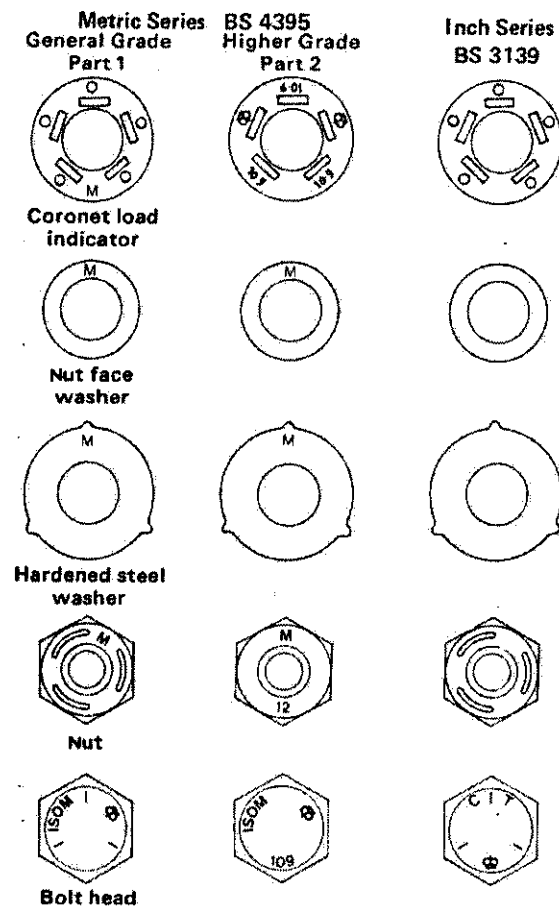




Sometimes it is more convenient to fit the 'Coronet' load indicator under the nut. A special nut face washer of similar hardness to the bolt head is placed between the protrusions of the load indicator and the nut. Then the same tightening procedure is followed.



**The Components Bolts, nuts, load indicators and washers are clearly marked according to grade.**



## Corrosion

High Strength Friction Grip Bolts, nuts, washers and load indicators will corrode if not properly protected. They must be kept in a clean, dry and well ventilated store. It is important that only the number required for immediate installation are issued from the stores in order that none are allowed to lie about the site and deteriorate.

Painting should be carried out at an early stage after tightening. This is particularly important in marine or other corrosive atmospheres.

The metallic coatings given in Table 3 are only intended to give temporary protection during storage and installation—early painting will still be required. Plated items must not be transferred from their cartons into hessian bags, as hessian tends to absorb moisture, and the damp conditions created can lead to rapid deterioration of the zinc or cadmium with harmful effect. Research has shown that susceptibility to stress corrosion and hydrogen embrittlement increases with tensile strength. The presence of a metallic coating lowers the threshold of the tensile strength at which these phenomena may occur. This means that in certain conditions a metallic coating may reduce corrosive resistance, rather than enhance it, and the specifier must take account of site environment in deciding the suitability or otherwise of a coating. This applies particularly to the higher strength items, viz., washers, higher strength bolts and load indicators. Special care must be taken in the storage and early protection by painting of these when coated.

## The Tools

Hand wrenches may be satisfactory for tightening smaller diameters of bolts, but power tools or torque multipliers must be used for sizes M22 and 7/8" diameter and larger. It is most important that impact wrenches have adequate capacity to tighten bolts within 15 seconds.

Prolonged impacting can damage the bolt assembly to such an extent that the bolt may be fractured.

In selecting a tool, it is wise to choose one which has a torque output in excess of the theoretical figure required for tightening the largest bolt for which it will be needed, thus making some allowance for loss of performance due to wear, air leakage, etc., and to help overcome the energy absorbed by higher than usual thread friction or 'springy' joints.

Most air wrenches require 1 cu. metre/min. (35cu. ft./min.) at a pressure of 690 kN/sq.m. (100 lb./sq. in.) at the tool for optimum performance. To maintain this delivery a 3/4" air line is usually required from the compressor to the tool, keeping the line as short as possible.

If tightening is not completed in the required 15 seconds, check for:

- Damaged or dry bolt and nut threads
- Poor fit of joint plies
- Bad alignment of holes causing bolt to trap
- Insufficient quantity of air supply
- Any restrictions or leaks on air line
- Excessive length of air line
- Blockage of gauze filter at tool air inlet

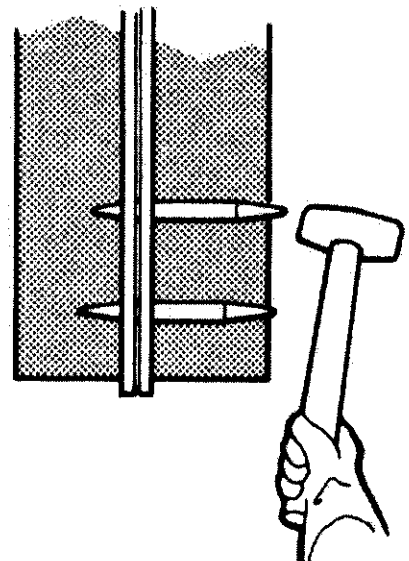
If the tool is sluggish, it must be blown through with paraffin to clean it and then re-lubricated with light oil

## Installation

Proceed as follows: -

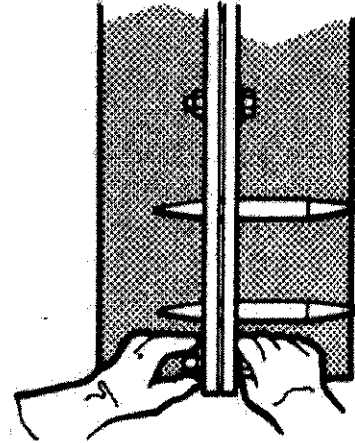
### Stage (1)

The members to be joined are brought together and the holes aligned with drift pins.



### Stage (2)

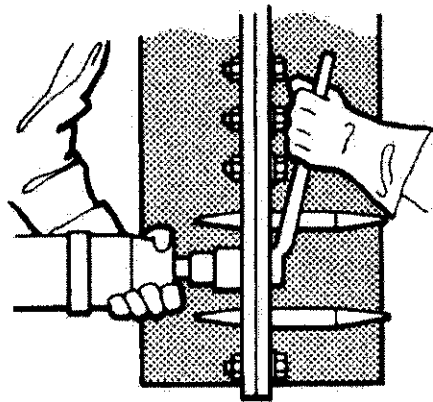
Sufficient bolts with there appropriate washers and load indicators are partially tightened in order to draw the members into close contact.



### Stage (3)

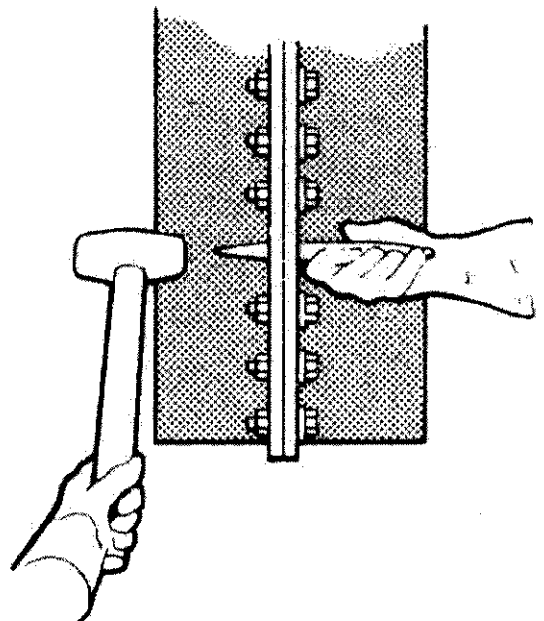
Fit the bolts into the remaining holes and tighten them until the average gap on each load indicator is not more than the figure quoted in Table 1.

N.B. Work from the centre of the joint outwards towards the free edges.



### Stage (4)

Knock out the drift pins and replace them with further bolts and tighten. In order to avoid trapping the bolts by joint slip, it is important that they should be tightened before the drift pins are knocked out.





## Installation Tips

- Check that all bolts, nuts, load indicators are of the required grade before fixing.
- Ensure that the bolts fit the holes freely—forcing the bolts into the holes by means of hammering would damage the threads.
- The load indicator protrusions must always bear against the bolt head or a nut face washer—NO OTHER WAY WILL DO.
- Never allow the bolt head to spin on the load indicator protrusions.
- The bolt with the load indicator fitted under the head must be inserted through the hole without using force, and the flat round washer and nut are then fitted. If the bolts have been properly stored, there will be sufficient residual oil on the threads, but if the threads are dry, rusty or dirty, they must be cleaned and re-lubricated to reduce thread friction. Care must be taken to avoid any lubricant getting on to the contacting surfaces of the joint.
- Tightening is continued until the AVERAGE load indicator gap is reduced to the figure given in Table 1. This may be measured with a feeler gauge, but with practice can soon be judged by eye with acceptable accuracy. If the gap is inadvertently completely closed, this need not be a cause for rejection, for general grade bolts. However, it must then be realized that the bolt is stressed nearer to the minimum ultimate load than would have been the case if a small gap had been left. For this reason it is better to leave a small gap.
- Using adequate capacity power wrenches and satisfactory thread condition, the tightening operation should be completed within 15 seconds. If it is not, check for dry, rusty or damaged threads, poor fit, bad hole alignment or for a tool fault.
- Where steelwork is to be left exposed, tightening, inspection and painting should be carried out within the shortest possible time to prevent corrosion.
- The 'Coronet' load indicator is a precision made measuring device and on no account should it be given any further treatment after leaving the supplier.
- The load indicator does not make the bolt any more difficult to tighten—it simply leaves a permanent witness that the bolt has been tightened to the correct tension.

## Inspection

The Inspector only needs to observe the installed bolts and satisfy himself that:

*For general grade bolts :-*

The average load indicator gaps are not larger than those given in Table 1. Usually it is only necessary to check two or three bolts out of a group with a feeler gauge and then judge the remainder by eye.

*For*

*higher grade Part 2 bolts :-*

The average load indicator gaps are within the limits given in Table 1. This inspection will ordinarily ensure that the specified bolt tightness has been obtained.

Where there is need for further confirmation of bolt tightness, some assemblies of bolts and load indicators may be tightened in the same manner as the bolts under inspection in a load cell to verify that:

*For general grade bolts :-*

The shank tension at the average gap given in Table 1 is not less than the minimum required by B.S. 4604 Part and B.S. 3294.

*For higher grade Part 2 bolts :-*

The shank tension at maximum and minimum average gap is within the required limits of B.S. 4604 Part 2

Inspection note:

Do not expect the load indicator gaps to be equal around the circumference. Due to the tightening operation the load indicator invariably pulls down more on one side than the other. The load indicator is designed to accommodate this and the AVERAGE gap will always give the correct tension.

The calibrated torque wrench method is not sufficiently accurate for inspecting load indicator tightened bolts, as it only measures resistance to turning. It should not be used in any circumstances

## **Final Note**

The recommendations detailed in this manual are a summary of our experience as to the best codes of practice, for using high strength friction grip bolts in steel structures.

The final responsibility for the specification and the use of High Strength Friction Grip Bolts must lie with the Designer, Consultant or Engineer, who must satisfy himself that what he is specifying is what he himself knows from his own experience to be suitable, for the particular application for which he is responsible.

## **References**

### **I**

B.S. 4395 High Strength Friction Grip Bolts, Metric Series,  
Part 1, General Grade.  
Part 2, Higher Grade (Parallel Shank).

B.S. 31 39 High Strength Friction Grip Bolts, Inch Series,  
Part 1, General Grade.

B.S. 4604 The Use of High Strength Friction Grip Bolts in Structural Steelwork, Metric Series,  
Part 1, General Grade.  
Part 2. Higher Grade (Parallel Shank).

B.S. 3294 The Use of High Strength Friction Grip Bolts in Structural Steelwork, Inch Series,  
Part 1, General Grade.

Cooper & Turner Structural Bolting Brochure

**Table 1. Load Indicator average gaps after tightening**

LOAD INDICATOR FITTING	B.S. 4395 METRIC SERIES			B.S. 3139 INCH SERIES
	General Grade Part 1	Higher Grade Part 2		General Grade
		Max.	Min.	
<i>Under bolt head</i> Black finish bolts	0.40mm	0.50mm	0.40mm	0.015in.
<i>All platings</i> Including spun Galvanized bolts	0.40mm	0.50mm	0.40mm	0.015in.
<i>Under nut with</i> <i>nut face washer</i> Black and all nut face washer finishes	0.25mm	0.35mm	0.25mm	0.010in.

At the average gaps shown the shank tension will be:

*For general grade bolts*

Not less than the minimum given in Table 2

*For higher grade Part 2 Bolts*

Within the tension limits given in Table 2

**Table 2. Shank tension**

Bolt Diameter	B.S. 4395 METRIC SERIES			B.S. 3139 INCH SERIES	
	General Grade Part 1	Higher Grade Part 2		General Grade	
	Min. Proof load	Min. 0.85 x min. proof load	Max. 1.15 x min. proof load	Bolt dia	Min. Proof load
mm	kN	kN	kN	in.	tons.
M16	92	104	140	1/2	5.37
M20	144	162	219	5/8	8.56
M22	177	200	271	3/4	12.67
M24	207	233	316	7/8	17.50
M27	234	303	409	1	23.00
M30	286	370	500	1.1/8	25.20
M33	-	459	621	1.1/4	32.00
M36	418	-	-	-	-

**Table 3. Metallic Coatings**

Finish	General Grade B.S. 4395 Part 1 B.S. 3139		Higher Grade B.S. 4395 Part 2		Coronet Load Indicators	Washers* B.S. 4395 B.S. 3139
	Bolts	Nuts	Bolts	Nuts		
Electro Zinc	<b>X</b>	<b>X</b>				<b>X</b>
Electro Cadmium	<b>X</b>	<b>X</b>		<b>X</b>		<b>X</b>
Spun Galvanised	<b>X</b>	<b>X</b>				<b>X</b>
Sheradised	<b>X</b>	<b>X</b>	<b>X</b>		<b>X</b>	<b>X</b>

\*Nut face washers are available only in the plain or sherardised finish

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