

BLIND BOLTING

Background and Summary of the Invention

5 This invention concerns the use of threaded fasteners, particularly the field of bolts adapted to be installed entirely from one side of a hole. Such fasteners are commonly referred to as blind bolts.

10 There is a need for threaded fasteners, particularly in structural steel applications, which can be installed from only one side of a hole so they may be used where the other side of the hole is inaccessible for some reason.

One type of fastener often used where access to one side of a hole is unavailable is that which is commonly referred to as a toggle bolt. It requires a hole significantly larger
15 than the bolt to be made and the threaded end of the bolt is then pushed through the hole while threaded to it is a toggle which folds out from the thread by spring assistance or by gravity and provides an arm or arms to bear against the far exit wall of the hole as the bolt is tightened. Although relatively inexpensive, toggle bolts provide relatively low strength in comparison with the size of the hole required and also exhibit
20 a wide variation in strength between apparently identical bolts. This makes them unsuitable for structural steel applications.

Other types of bolts which can be installed from one side of a hole include those commonly called blind bolts. These have evolved over many years and may be suitable
25 for structural applications. Examples are described in Australian patent specifications AU-A-67133/90, AU-A-20458/92 and AU-A-20279/95. However a major problem with bolts of that type is that the failure load has a high dispersion. Also these bolts are relatively expensive to manufacture.

30 An aim of the present invention is to provide fasteners which overcome these difficulties.

Accordingly, in one aspect the invention provides a method of installing a threaded fastener from one side of a hole through a substrate comprising:

- (i) passing a first portion of the fastener completely through the hole from said one side, being the near side of the hole, to the far side of the hole;
- 5 (ii) supporting said first portion on the far side of the hole by way of support means attached to the first portion and extending through the hole;
- (iii) thereafter passing an additional portion or portions of the fastener completely through the hole and supporting said additional portions with support means extending through the hole;
- 10 (iv) causing said first and additional portion or portions to assemble to form the threaded fastener having a head larger than the hole on the far side of the hole, a shank within the hole, and a tail carrying a thread on the near side of the hole;
- (v) engaging a nut with said thread on the near side and rotating the nut to tension said fastener; and
- 15 (vi) detaching the support means from the fastener.

The first portion may comprise a bolt-like component having an enlarged head portion at one end and a threaded tail portion at the other end and be passed head first through the hole in the substrate. The support means may comprise a shaft which is threadedly
20 engaged with the first portion of the fastener by way of a second thread portion on the tail. The second thread preferably has a smaller diameter than the thread used to tension the fastener, and be of opposite hand. Preferably the second thread is a male thread carried on the tip of the fastener.

25 The additional portion is preferably a washer-like collar having a hole therethrough and the support means passes through the hole in the collar as the collar is being passed through the hole in the substrate. The collar preferably comprises two rigid halves joined by flexible hinge portions, and the collar folds to lie either side of the support means as the collar is being passed through the hole.

The hole through which the fastener is fastened may be the in-line combination of a plurality of shorter holes. The attachment of the support means to the fastener may be magnetic.

- 5 Preferably the hinge portions are formed by a flexible material, preferably an elastomer, applied to a face of each half of the collar said face being at right angles to the axis of the hole through the collar. Preferably the elastomer is applied to a recess or recesses let into the relevant face. Prior to said installation, the flexible hinge portions may be supported by thin rigid webs which are fractured by a user before the
10 collar is folded around the support means.

Preferably the support means comprises a shaft of a tool having a notch or notches onto which the collar latches, and the shaft is thinned, preferably flattened, where the collar latches on.

15

- The tool may have a sleeve axially slidable along the shaft and, after the collar has passed into the hole in the substrate, the sleeve is slid over said thinned portion and engaged with the shaft beyond each end of the thinned portion, to increase the torsional strength of the shaft while it restrains the first portion of the fastener from
20 rotating as the nut is tightened. Preferably the shaft is separated from the fastener by rotating the shaft in the same direction as that taken by the nut as it was tightening.

- Preferably the collar has a boss or other axial protrusion which engages into the hole through the substrate when the fastener is tensioned. A sleeve may be fitted inside the
25 hole around the fastener. Preferably a washer is provided between said nut and said substrate and, as the fastener is tightened, a boss on the washer engages into the hole through the substrate.

- Said first and additional portions of the fastener may each comprise a radial segment of
30 a bolt-like component having an enlarged head portion, and each segment is passed through the hole in the substrate with the head portion first. The radial segments may

be supported on the far side of the hole by a separate thin rod or wire attached to the threaded end of each radial segment.

Brief Description of the Drawings

5

Examples of the invention will now be described with reference to the attached drawings where:

- Figure 1 is an exploded view of a fastener assembly according to a first embodiment of the present invention;
- 10 Figure 2 is an exploded view of the fastener shown in Figure 1 together with its installation apparatus;
- Figure 3 shows one component of the assembly shown in Figures 1 and 2;
- Figures 4 and 5 show the component of Figure 3 at various stages of folding;
- Figure 6 is a cross section through an assembled form of the components shown in
- 15 Figure 1.
- Figure 7 shows an alternative configuration for the component of Figure 3;
- Figure 8 is a cross section through part of an assembled fastener showing the installed position of the component shown in Figure 7;
- Figure 9 is a cross section similar to Figure 8 but with an alternative to the
- 20 component shown in Figure 7;
- Figure 10 is a cutaway partly exploded view showing a fastener according to a more preferred embodiment of the invention during installation;
- Figure 11 is a partial see-through side view of the installation tool shown in Figure 10;
- 25 Figure 12 is a side view of a bolt component of the fastener shown in Figure 10;
- Figure 13 is a cross section view of a washer component of the fastener shown in Figure 10;
- Figure 14 is a cross section view of a collar component of the fastener shown in Figure 10;
- 30 Figure 15 is a view along the bore axis of the collar shown in Figure 14 with hidden lines shown dashed;
- Figure 16 is a view of an alternative configuration of the collar shown in Figure 15;

Figure 17 is a side view of a bolt in accordance with a further embodiment of the present invention; and

Figure 18 is an end view in the direction shown by the arrow A in Figure 17.

5 Detailed Description of the Preferred Embodiments

Referring to Figure 1, a fastener assembly comprises a bolt 2, nut 3 and washer 4. The bolt joins two steel plates 5 and 6 by passing through holes 7 in them and being tensioned. A sleeve 19 fills the annular gap between the bolt 2 and the walls of the
10 holes 7.

The bolt 2 has a shank 8 with, at one end, a head 9 and, at the other end, a tail 10 which carries a conventional right-handed thread 11 to suit the nut 3. The head 9 consists of a crown 12 integrally formed with the shank 8 and a collar 14.

15

As best seen in Figures 3 to 5, the collar 14 has two half-collars 16 linked together by a backing strap 18 tightly attached to the half-collars. The half-collars 16 are preferably made from hardened steel and the strap 18 made from thin spring steel strip or a strong plastics material such as Mylar. The strap has some resilient property but
20 this need not be sufficient to fully open out the collar to the position shown in Figure 3. After being folded to the position in Figure 5 it is sufficient that the resilience is sufficient to return it to the Figure 4 position.

Figure 6 shows the bolt 2 extending through the plates 5 and 6 with the washer 4 and
25 nut 3 engaged. The sleeve 19 neatly fills the annulus between the bolt and the holes 7 in the plates so that there is no possibility of movement lateral to the hole. This allows the bolt to be used in a shear loading situation. If there is little or no shear component to the loading, then the sleeve may be omitted from the assembly if required. The sleeve 19 is sized to be a little shorter than the total length through the plates so that it
30 is not compressed during tightening of the nut 3. In order to show individual components more clearly, Figure 6 has been drawn with the nut wound on to the bolt just prior to commencement of tensioning.

Referring to Figure 2, the additional apparatus used to install the bolt 2 comprises an extension bar (or shaft) 20, a handle 21 and a spanner (not shown) to suit the nut 3.

- 5 The extension bar 20 has a head portion 22 and a tail portion 24 separated by a thinned or waisted portion 26. The tail portion 24 has a left handed male thread 28 on its end. The tail 10 of the bolt has a short bore 30 which carries a left handed female thread and this engages with the male thread 28 on the tail portion 24.
- 10 The crown 12 of the bolt is a gentle clearance fit through the holes 7. To install the bolt completely, the extension bar 20 is first screwed into the tail of the bolt and the bolt is inserted through the aligned holes 7. The bolt 2 passes fully through the holes 7 using the extension bar 20 to support it on the far side. The collar 14 is then placed on the head 22 of the extension bar, in the orientation required on the far side of the hole,
- 15 and is pushed along the bar until it reaches the waisted portion 26. The waist is a thin flat portion with its main faces oriented vertically when positioned as shown in Figure 2. At the waist the collar is folded to hinge at 32 along the backing strap 18 and is aligned to pass through the hole 7 when the waisted portion is pushed through the hole. On the far side of the hole the resilience of the strap causes the collar to open to
- 20 some degree between a little less than shown in Figure 4 and fully open as shown in Figure 3. The extension bar 20 is then pulled to bring the shank 8 of the bolt back into the hole, with the crown 12 of the head pressing on the collar 14 to fully open it.

- The sleeve 19 is then fed onto the extension bar, along over the bolt, and then into the
- 25 hole 7. The outside and inside diameters of the sleeve 19 are selected to be a loose (but not sloppy) sliding fit to both the hole and the bolt respectively. The washer 4 and nut 3 are then fed onto the extension bar, engaged with the thread 11 and tightened with a spanner. The handle 21 has a fork 34 which engages a pair of diametrically opposed flats 37 on the tail portion of the extension bar 20 to prevent
- 30 rotation of the bolt during tightening of the nut 3.

After the bolt is tightened to the desired tension, the extension bar may be unscrewed using the handle 21 and attached to the next bolt to be installed.

In the above description, the external main thread 11 on the bolt is right handed whereas the thread 28 on the extension bar and its mating thread in the bore 30 are left handed. It will be appreciated that the handedness of these threads may be reversed if wished, providing the opposite relationship is retained.

Typical nominal sizings for a 23 mm diameter hole in the steel plates 5 and 6 would be:

10	diameter of bolt crown :	22 mm
	diameter of bolt shank:	16 mm
	outside diameter of collar:	36 mm if 4 mm thick
		34 mm if 5 mm thick
	inside diameter of collar:	16 mm

15 It will be understood that these are nominal sizes and allowance must be made for appropriate clearances and tolerances.

The collar shown folded in Figure 2 is oriented so that the hinge 32 is inclined downwards towards the crown of the bolt. At the completion of installation the backing strap 18 will be pressed between the collar 14 and steel plate 5. Alternatively the collar 14 may be placed onto the extension bar in the opposite direction so that the backing strap finishes being pressed between the bolt crown 12 and collar 14. With this alternative, when the collar is folded at the waisted portion during installation, the hinge 32 is inclined upwardly towards the crown of the bolt.

25 If required, more than one collar may be installed on a bolt in order to increase the strength of the bolt's head of which the collar(s) form a part. The bolt thus has a head consisting of the crown, formed integrally with the shank, plus two or more collar layers captive but not affixed. An advantage of using such a collar in two portions, where each portion has two semi-circular halves, is that because it is unlikely that both portions will align with their hinges in the same plane, the assembly is stronger with

less likelihood of the half-collars separating. Some embodiments of such an arrangement are discussed later in this specification.

Referring to Figure 7, the alternative collar 40 shown is very similar to that of Figure 3. A significant difference is that it carries a pair of flanges 42 on one face of the collar adjacent the bore. These curved flanges do not extend for the full perimeter of the bore in the collar and they thus take the form of a type of discontinuous boss on the collar. The width of the flanges 42 in the diametrical direction is slightly less than the clearance between the shank 8 of the bolt and the hole 7. The collar is thus able to take up the position shown in Figure 8 whereby the flanges 42 serve to prevent the collar and the bolt from moving relative to the hole.

Referring to Figure 9, the collar in this embodiment consists of a pair of inter-engaged collar portions 50 and 51. Collar portion 50 has its backing strap 53 bearing against the crown 12 while portion 51 has its backing strap 54 bearing against the plate 5. One collar portion 50 is slid through the hole with its hinge inclined downwards towards the crown of the bolt while the other portion 51 is slid through the hole with its hinge inclined upwards towards the crown of the bolt.

The mating faces 57 and 58 of the collar portions 50 and 51 respectively are circumferentially ridged in a manner that they neatly nest together. An advantage of using such a collar in two portions, where each portion has two semi-circular halves interlocked with the other portion, is that because it is unlikely that both portions will align with their hinges in the same plane, the inter-locking of the ridging will prevent any tendency for the halves to separate by tearing along the hinge line.

Collar portions 50 and 51 are not of the same shape. The ridgings are complementary and this cannot be achieved if the collar portions 50 and 51 have identical forms.

Alternative interlocking configurations of ridging that may be used include radial patterns, and these can provide the advantage of being able to use collar layers of

identical form, and/or aligning the ridging so that the hinges of the two layers cannot align into the same plane if the layers are properly nested.

Referring to Figure 10, the fastener shown is being installed through two steel plates 72 and 73 by a person who has access to only the near side 74 of the plates. Holes 75 and 76 have been drilled in the plates 72 and 73 and after installation the fastener will pass through those holes and clamp the plates firmly together. The bolt 79, which is also shown in Figure 12, has a head 80, shank 81, and tail 82. The main thread 83 is a right-handed thread which has been rolled on to the full diameter of the shank of the bolt. Extending from the main threaded portion, is a short section of a second thread 84 which has a smaller diameter than the main thread. This second and minor thread is a left-handed multi-start thread.

The fastening tool 89 comprises a handle 93, threaded socket 95 and a shaft 91 extending between the handle and socket. The handle is designed as an L-shape for ease of holding and torquing. The socket 95 carries a multi-start left-handed thread which mates with the minor thread 84 on the tip of the bolt.

Shown mounted on the tool are a nut 99, near-side washer 101 and the collar 86. The preferred structure of the collar is shown in Figures 14 and 15, an alternative is shown in Figure 16, and both will be described later in this specification.

The bolt 79 in Figure 10 carries a male left-hand thread to engage the socket on the tool whereas in Figure 2 the bolt 2 has a female left-hand thread. This makes bolt 79 easier and cheaper to manufacture than bolt 2.

Referring to Figures 10 and 11, the tool 89 is constructed primarily from hexagonal section steel stock with a plastic handle 93 and internally threaded socket 95 attached. A flattened section 110 is forged into the hex steel near the threaded socket. The height of the flattened section 110 is the same as the major diameter of the hex bar from which it is formed, and the thickness of the flattened section is about one tenth of its height. The flattened section 110 carries two V-shaped notches 114 and two

rectangular notches 112. These serve as nesting places to locate the collar (as shown in Figure 10) so that the collar is more easily pushed through the hole by the tool. The notches also allow the collar to be nested onto the tool with the collar's hinge aligned more parallel to the tool and thus allows the diameter of the collar to be increased for any given sized hole.

A disadvantage of thinning the metal of the tool in order to allow the collar to be folded over it, is that it means the tool in that region has a much reduced resistance to twisting. This weakening effect is made worse by the relatively large notches 112 and 114 which remove further material. This disadvantage has been limited by incorporating a sleeve 97 which is a sliding fit over the hex section and captive on the tool. In Figure 11 the sleeve 97 is shown in phantom to aid clarification. When positioning the collar through the hole, the sleeve 97 is slid back towards the handle 93, but when it is necessary to apply more torque, such as when restraining a bolt from turning while its nut is being tightened, the sleeve is slid down towards the socket end so that the sleeve spans the flattened section and engages the hex section at 116 and 118 which are just beyond each end of the thinned portion 110.

To install the bolt 79, first the nut 99, the near-side washer 101, and the collar 86 are placed onto the shaft of the tool and then the threaded tip 84 of bolt 79 is screwed into the socket 95 on the tool end. Such a thread minimises the possibilities for cross-threading and minimises the number of turns required for the bolt to lock into the tool. This is made rapid and easy by using a multi-start thread such as a two-start or three-start thread. The bolt is then fed in its entirety head first through the holes 75 and 76 from the near-side to the far side.

The tool 89 as described above is of mainly metal construction with a plastic handle. It may also be constructed entirely from appropriately chosen engineering plastics material(s). This could provide substantial savings in manufacture.

As shown most clearly in Figure 13 the washer 101 has a boss 103 extending from the face 104 in contact with the steel plate 72. The outside diameter of the boss is slightly

smaller than the diameter of the hole 75, so the boss fits neatly into the entry of hole 75 and thus serves to positively locate the position of the bolt central to the hole in the same manner as the collar 86 and the washer 46 act as shown in Figure 8.

- 5 Figure 10 shows no sleeve equivalent to sleeve 19 in Figure 6, but it will be understood that such a sleeve may be optionally fitted, and is in fact preferred for joins under high shear loading.

With reference to the collar 86 shown in Figure 10, a more detailed description will
10 now be given with reference to Figures 14 and 15. The collar is manufactured from a washer the same as that described with reference to Figure 13. A wide but shallow annular channel 120 is machined into the face 122 and this is filled with an elastomeric material. Many elastomers are suitable, the main requirement being the need to adhere
15 to steel and have good elastic properties. A conventional silicone rubber sealant material is satisfactory. On the opposite face of the collar a boss 124 is raised and this again is to locate into the entry of the hole 76 in order to correctly centre the bolt in the hole. Cut diametrically into the collar from the boss side is a slot 126 of about 1mm width. The slot passes almost completely through the collar, penetrating through
20 the bottom of channel 120 but stopping approximately 0.3mm short of reaching the face 122 at the bottom of the slot. Slight flats 128 can be seen on the periphery of the collar and these are used as a positive retaining means while their slot is being machined. When the collar is to be used for a fastener, the operator first bends the collar easily in the fingers, boss outwards, and this fractures the four small steel links
25 at 132 to 135. The elastomer however does not break and its elastic properties are such that it returns the collar to a substantially planar form. The above described configuration allows the elastomer in the hinge area to be kept stress free during transport and shipping of the components and it is only when the collar is to be used that the elastomer is caused to flex, so minimising the possibility of premature or unexpected elastomer failure.

30

Referring further to Figures 13 and 14, some of the faces of the collar 121 and washer 101 may be roughened in some manner to increase friction between facing steel

surfaces and therefore reduce the tendency of the fastener to spin as the nut is tightened. The faces to be roughened are flat faces 122 and 123 on the collar 121 and face 104 on the washer 101. In contrast, face 105 on the washer should be kept smooth in order to reduce friction between the nut 99 and the washer. Suitable
5 roughening may be achieved by use of knurling, embossing or grooving techniques,

The embodiment of the collar shown in Figure 16 is the same as that shown in Figure 15 except that instead of the wide channel filled with elastomer as a full circle, a pair of flat bottomed recesses machined into the face 122 are filled with elastomer and the
10 component activated in the same way by snapping a thin web of metal.

Referring to Figures 17 and 18, the bolt 160 of this embodiment has a shank 161 with, at one end, a head 162 and, at the other end a tail 163 which has a thread 164 to suit an appropriate nut (not shown). The bolt is divided radially into three segments 167,
15 168 and 169 of equal size.

By means of a thin rod or wire attached to the tail end of each of the segments the segments may be pushed, head end first, and one at a time, completely through the required hole, leaving only the attached rods in the hole. After the third segment is
20 pushed through, the three rods may be simply manipulated in order to correctly align them with each other before pulling the tail ends of the segments together back through the hole. A washer and nut may be fed over the rods to engage and tighten upon the thread running around the perimeter of the three segments.

25 For the purposes of manufacturing, the segments 167, 168 and 169 of the bolt may be made from three identical forgings which are then brought together in the required relationship for the thread to be cut or rolled thereon. It will be appreciated that the segments thus form a mating trio whose relative positions should be maintained at installation in order for the threads to properly align. The segments of each bolt would
30 be sold as a matched set and provision needs to be made for their correct relative positions to be determined at the time of installation. This could be by way of each of

the three rods having a different cross section and then having a gauge or template by which the position of the different rod cross sections may be determined.

- The above description in relation to Figures 17 and 18 refers to the bolt having three segments. Similar but less preferred alternative configurations may use more than three segments, and four segments would be the most favoured of these. While the additional segments may be more difficult to assemble remotely on the far side of the hole, they would provide the advantage that a larger head could be created on the bolt.
- 10 Throughout this specification, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.
- 15 Finally, it is to be understood that various alterations, modifications and/or additions may be introduced into the constructions and arrangements of parts previously described without departing from the spirit or ambit of the invention.

CLAIMS

1. A method of installing a threaded fastener from one side of a hole through a substrate comprising:
 - 5 (i) passing a first portion of the fastener completely through the hole from said one side, being the near side of the hole, to the far side of the hole;
 - (ii) supporting said first portion on the far side of the hole by way of support means attached to the first portion and extending through the hole;
 - (iii) thereafter passing an additional portion or portions of the fastener completely
10 through the hole and supporting said additional portions with support means extending through the hole;
 - (iv) causing said first and additional portion or portions to assemble to form the threaded fastener having a head larger than the hole on the far side of the hole, a shank within the hole, and a tail carrying a thread on the near side of the hole;
 - 15 (v) engaging a nut with said thread on the near side and rotating the nut to tension said fastener; and
 - (vi) detaching the support means from the fastener.
2. A method according to claim 1 wherein said first portion comprises a bolt-like
20 component having an enlarged head portion at one end and a threaded tail portion at the other end and said first portion is passed head first through the hole in the substrate.
3. A method according to claim 2 wherein the support means comprises a shaft
25 which is threadedly engaged with the first portion of the fastener by way of a second thread portion on said tail.
4. A method according to claim 3 wherein said second thread has a smaller diameter than, and is of opposite hand to, said thread used to tension the fastener.
- 30 5. A method according to claim 4 wherein said second thread is a male thread carried on the tip of the fastener.

6. A method according to any one of the preceding claims wherein said additional portion comprises a washer-like collar having a hole therethrough and the support means passes through the hole in the collar as the collar is being passed through the hole in the substrate.

7. A method according to claim 6 wherein the collar folds to lie either side of the support means as the collar is being passed through the hole.

8. A method according to claim 7 wherein the collar comprises two rigid halves joined by flexible hinge portions.

9. A method according to claim 8 wherein the hinge portions are formed by a flexible material applied to a face of each half of the collar said face being at right angles to the axis of the hole through the collar.

10. A method according to claim 9 wherein the flexible material is an elastomer.

11. A method according to claim 10 wherein the elastomer is applied to a recess or recesses let into each said face.

12. A method according to any one of claims 8 to 11 wherein prior to said installation, the flexible hinge portions are supported by thin rigid webs which are fractured by a user before the collar is folded around the support means.

13. A method according to any one of claims 6 to 12 wherein said support means comprises a shaft of a tool having a notch or notches onto which the collar latches.

14. A method according to claim 13 wherein the shaft is thinned where the collar latches on.



15. A method according to claim 14 wherein the thinning of the shaft is a flattening.

16 A method according to any one of claims 14 to 15 wherein the tool has a sleeve axially slidable along the shaft and, after the collar has passed into the hole in the substrate, the sleeve is slid over said thinned portion and engaged with the shaft beyond each end of the thinned portion, to increase the torsional strength of the shaft while it restrains the first portion of the fastener from rotating as the nut is tightened.

17. A method according to any one of claims 3 to 16 wherein the shaft is separated from the fastener by rotating the shaft in the same direction as that taken by the nut as it was tightening.

18. A method according to any one of claims 6 to 17 wherein the collar has a boss or other axial protrusion which engages into the hole through the substrate when the fastener is tensioned.

19. A method according to any one of claims 6 to 18 wherein a sleeve is fitted inside the hole around the fastener.

20. A method according to any one of the previous claims wherein a washer is provided between said nut and said substrate and as the fastener is tightened, a boss on the washer engages into the hole through the substrate.

21. A method according to any one of the previous claims wherein a washer is provided between said nut and said substrate and the surface of the washer in contact with the substrate is roughened to increase the friction between the washer and substrate.

22. A method according to any one of claims 6 to 21 wherein the surfaces of the collar which contact the substrate and said first portion are roughened to increase the



friction between the collar and the substrate and between the collar and the first portion.

23. A method according to claim 1 wherein said first portion and said additional
5 portions of the fastener each comprise a radial segment of a bolt-like component having an enlarged head portion, and each segment is passed through the hole in the substrate with the head portion first.

24. A method according to claim 20 wherein said radial segments are supported on
10 the far side of the hole by a separate thin rod or wire attached to the threaded end of each radial segment.

