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Operation & Maintenance Manual
FLI Screw Piles, Driven Piles & Micropiles

Prepared for: General Guidance

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Revision	Date	Prepared By	Checked By	Authorised By
01	28/02/2020	G. Gardner	R. Steel	T. Burden

CONTENTS

1.0 INTRODUCTION

FLI Structures (FLI) design and supply a range of products, including towers, steel grillages and frames, monopoles, screw piles & other steel piling systems. These products provide a safe foundation and support for signals, antennas and other services.

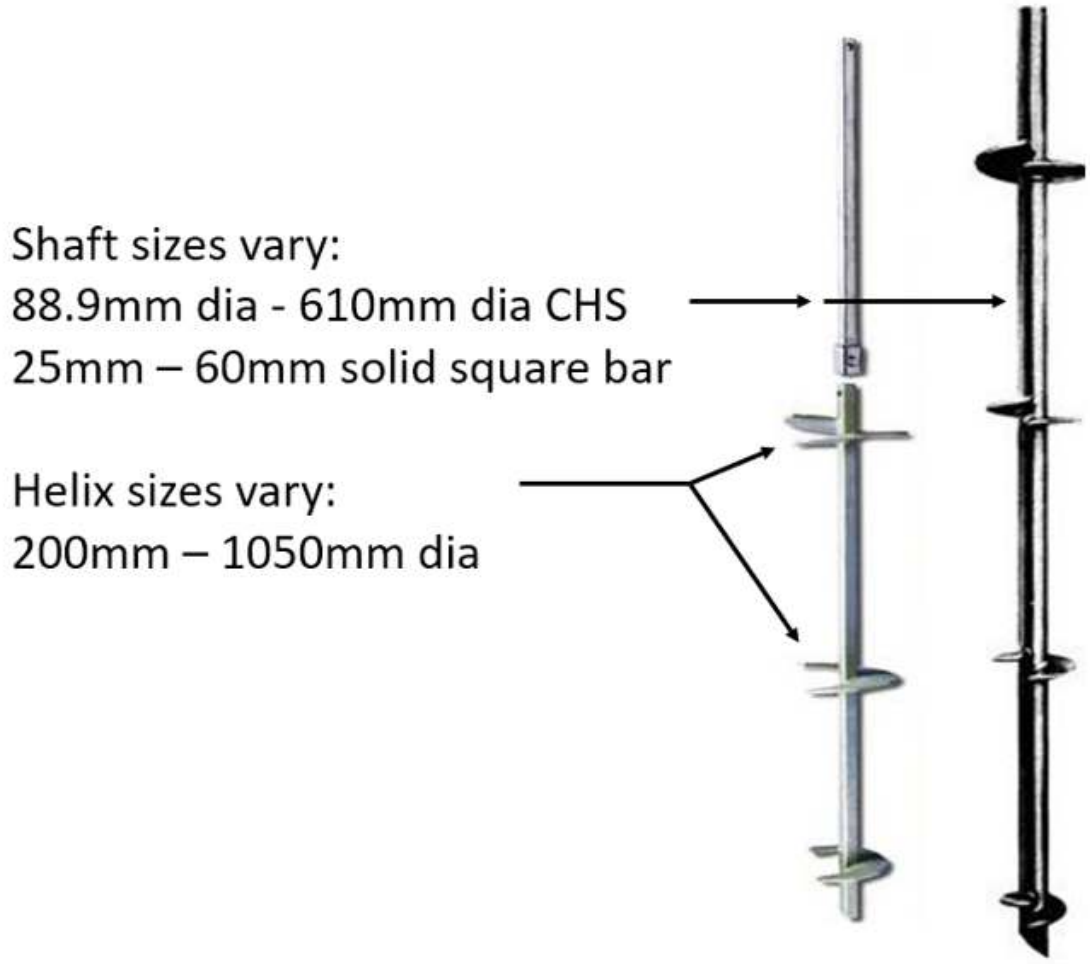
This document contains general information required for the safe Installation and maintenance of FLI Screw Piles, Driven Piles and Micropiles. This document includes a summary of the designer's residual hazards, a maintenance statement and general installation guidance.

Furthermore, this document is intended only to provide general guidance and is not a method statement. It is essential that FLI's products are installed using proven techniques by competent Contractors. The installers should provide a method statement outlining the proposed method prior to commencing any works. The statement of Designers Residual Hazards addresses general issues regarding the installation, maintenance and dismantling of structures, however all projects will require task specific risk assessments.

2.0 DESCRIPTION

FLI Screw Piles, Driven Piles and Micropiles are typical steel foundations for super structures. Invariably these piles are hot dip galvanised. On many occasions they are also painted.

Screw Piles are made up from bolted-together steel sections that generally connect to an interface plate – to which the structure base or grillage connects. FLI screw piles are as follows:



Micropiles are typically Ischebeck Titan type grouted piles:

And driven piles are typically Circular Hollow Section piles (pipe or tube) with an adaptor to connect the structure to the pile:

In most cases multiple piles are connected together via a grillage to form a support for a structure. In these cases, the piles are usually connected to the grillage via a boot arrangement, as illustrateed in the adjacent image and the photos that follow:

Single piles Piles are used to support free-standing poles, lighting columns, signal posts, level crossing barriers, signage and the like. In these cases, the structure usually connects directly to the pile via a welded cap plate:

Piles can also be used to support platforms, cabinets and retaing walls:

3.0 INSTALLATION

It is essential that the structure is installed using proven techniques by competent Contractors, and to this end installation must be carried out by FLI trained operatives.

Detailed installation guidance is contained in the FLI Document 'Screw Pile Users Guide', FLI document number TRN0408, which are issued to operative during the training course. Copies are available on request.

Refer to the relevant General Arrangement drawings for details of the pile layout, elements and fixings.

Refer to Residual Risks and any site-specific Risks and Hazards prior to determining the preferred installation method for each site.

3.1 Bolt Configuration

Bolt assemblies supplied by FLI Structures are typically Grade 8.8 spun galvanised to BS EN ISO 10684:2004 and usually comprise a Bolt, Nut and flat washer for use under the nut. Spring washers are not supplied, nor desired.

U-Bolts and N-Bolts are typically Grade 4.6. and comprise the shaft, and one washer and 2 nuts per threaded end, the second nut being used as a lock nut.

Special bolts, fixings and configurations are utilised from time to time, as detailed on the General Arrangement Drawing. Where special fixings are supplied, appropriate tightening methods must be used.

3.2 Bolt Tightening – Ordinary bolts (non-preloaded)

Refer to 'Guidance Notes for Tightening Non-Preloaded (Ordinary) Bolts' Document No. FLI-GN-0007.

3.3 Bolt Tightening – Pre-loaded Bolts

Pre-loaded bolts shall be tightened in accordance with a specific method appropriate to the bolt assembly type.

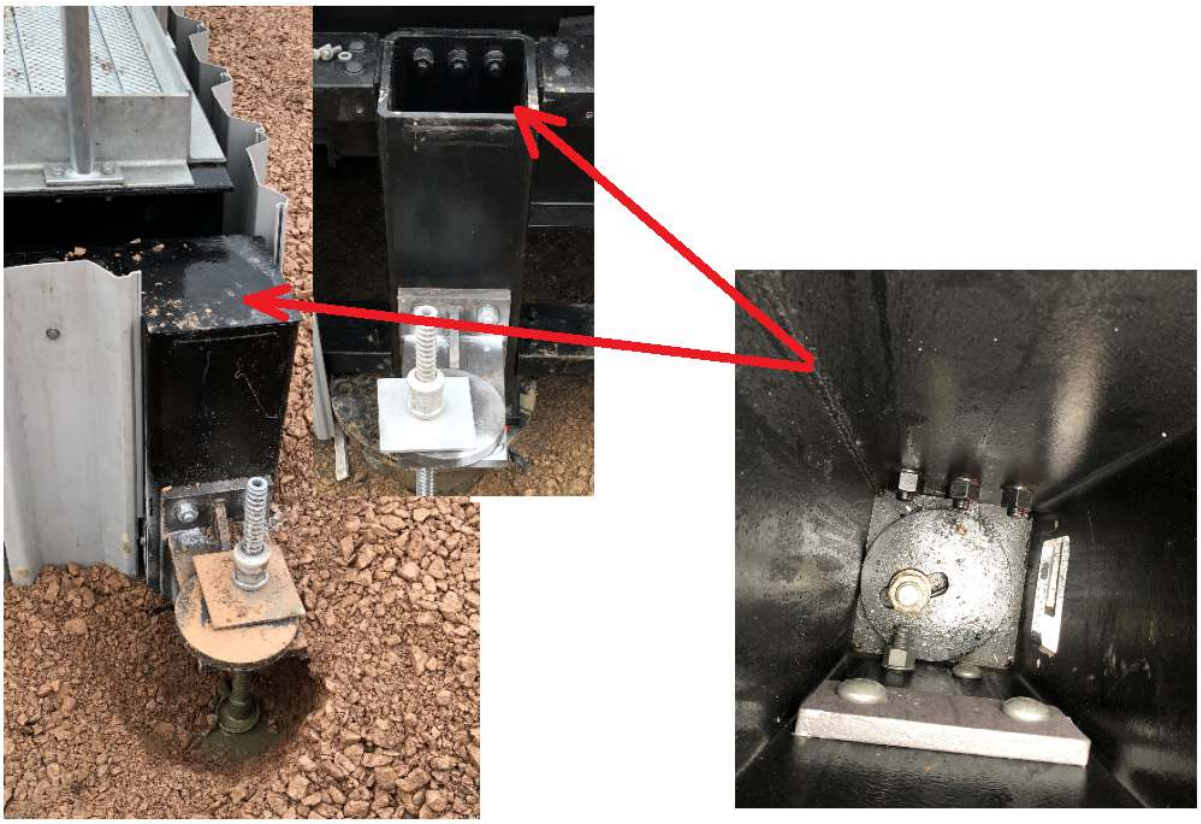
4.0 MAINTENANCE AND INSPECTION

As a minimum, the following items are to be examined intervals no greater than 2 years:

Item	Description
Earthing	The earthing system must be checked for electrical resistance in accordance with the original customer specification.
Corrosion, Distress and Bolt Tightness	Members and connections shall be inspected for corrosion and any form of distress, e.g. bent or fractured members. A 5% representative sample of all structural bolts shall be tested for tightness, and if there are any problems, check another 5% of remaining sample. If further problems are encountered all bolts in similar locations must be checked and tightened. Preloaded bolts shall be visually inspected to ensure that the bolt has been fitted correctly.
Galvanising and Painting	Members shall also be checked for signs of any damage to the galvanised surface. Any damaged surface shall be identified and remedial measures proposed. Refer to the following section 5.1 for guidance.

Special care must be taken to check for any signs of loose connections or distress to buried parts, looking for signs of movement or discoloration from corrosion. If any doubt exists, further investigation should be undertaken, which may necessitate local excavation.

Remember to inspect parts behind covers, an example of which is shown below.



5.0 DESIGNERS STATEMENT OF RESIDUAL HAZARDS

Design Residual Hazard	Description	Activity
Tripping	It is likely there will be trip hazards in the form of uneven ground, and other encumbrances protruding from the surface. (In some cases piles and grillages).	Installation Maintenance Dismantling
Use of inappropriate lifting techniques or equipment	Injury or product damage can result from employing inappropriate lifting techniques or equipment. The weights of individual elements and assemblies are shown on the relevant general assembly drawings.	Installation Dismantling
Handling heavy individual pieces	Injury could result from manual lifting of heavy items. Individual elements have been limited in weight as much as is possible. The weights of the items are listed on the relevant General Arrangement Drawing (GA)	Installation Dismantling
Injury from Vehicle and Plant Movements	Vehicles and Plant is likely to be operating around the site, and serious injury can result from inappropriate man-machine interfaces.	Installation Maintenance Dismantling
Use of under strength bolts	The structural bolts used on all FLI general products are generally grade 8.8. Substitute bolts from other sources shall not be used or structure failure could result.	Installation Maintenance
Use of hazardous material: touch-up paint and zinc rich paint	Damage to the galvanised coating can be repaired using zinc rich paint. Painted products are similarly repaired using touch-up paint. Inappropriate use of these materials can cause harm to operatives or the environment.	Installation Maintenance
Falls from height	Many structures require working at height, or pose a potential path for the general public to access unsafe areas. The use of unsuitable fall arrest systems or climbing techniques can result in falls. Inadequate security can give the public access to unsafe locations.	Installation Maintenance Dismantling
Falling objects from height	Items can be dropped by operatives working at height. This can include tools, bolts, structural items or equipment. Falling items can seriously injure persons in the fall zone.	Installation Maintenance Dismantling
Use of incomplete steps	Climbing steps or access equipment before the structure is fully installed can result in serious injury or death.	Installation Dismantling
Lightning strikes	Serious injury can result if structures are worked on during electrical storms or if the earth lugs provided at the base of the structure are not connected to the earthing system.	Installation Maintenance Dismantling
Collapse during dismantling	Structures can collapse unexpectedly if dismantled in an inappropriate manner. A competent person must always prepare a suitable method for dismantling.	Dismantling

A full risk assessment or each of the relevant identified hazards above and any other hazards that present themselves needs to be completed by the inspector and/or maintainer.

This list is not exhaustive and site-specific risks should always be considered.

5.1 Galvanising Coating Repair

These notes are an example only and the relevant manufacturer's product details and BS EN ISO 1461 should be referenced.

Repair Materials:

- Zinc rich paint (Manor Coating Systems or equivalent).
- Zinc sheen aerosol spray.
- Paint brushes.
- Protective gloves.
- Wire brushes.
- Sheets of emery paper.
- PPE as identified by task Risk Assessments shall also be used.

Repair Procedure:

1. Visually inspect all galvanising components to identify areas of coating damage.
2. Wire brush any damaged areas to remove loose coating material, signs of staining and corrosion products.
3. Exposed steel and the edges of any mechanically damaged areas are to be abraded with emery paper and the edges 'feathered' to provide a keying surface.
4. Clean area of damage with a clean cloth removing all dust/dirt from damaged area.
5. Observe good painting practice and do not apply paint in wet or damp conditions, or when the air temperature is below 5°C.
6. Apply 2 coats of zinc rich paint to the repair area (Touch dry approximately 1 hour). The total Dry Film Thickness (DFT) shall be no less than 100µm. (as per Clause 6.3 of BS EN ISO 1461:2009)
7. When dry, the painted area should be over sprayed with a zinc sheen spray to give a similar appearance to the galvanise coating. Note that when first applied, zinc sheen spray may appear bright but will fade quite quickly to match the galvanised surface.

Notes:

a) Superficial marks such as band staining and footmarks should be wiped clean and sprayed with zinc sheen.
b) White rusting rarely progresses past the superficial stage and will generally wear off in normal weather. No remedial treatment is required for light white rusting.
c) White rusting which has progressed past the superficial stage is characterised by a noticeable darkening and apparent etching of the galvanised coating. In such cases less than 5% of the galvanised coating has been removed and repair may be limited to removal of the white rust by wire brushing and over spray of the affected area with zinc sheen.
d) Severe white rust is characterised by heavy oxide deposits, with the area underneath almost black and showing signs of red rust.

5.2 Removal/Decommissioning

To remove the structure and decommission the site, typically, the reverse of erection procedures should be followed. A new Method Statement must be produced (by an appropriate authority) that takes into consideration any changes to the site and to the structure since the original design and construction (as this may impact on plant that can be used, space within which the decommissioning team can operate and the types of risk present on site).

Care should be taken to identify primary, secondary, tertiary (etc.) structural members to ensure that the dismantling process is safe and does not lead to instability, partial or total collapse of the structure. If in doubt, professional advice must be sought.

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Guidance Notes for Tightening Non-Preloaded (Ordinary) Bolts

Prepared for: General Guidance

Document No: FLI-GN-0007

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00	22/5/2018	T. Burden		For Comment
01	31/05/2018	T. Burden	R. Steel	1st issue

CONTENTS

1.0 INSTALLATION GUIDANCE

Refer to the relevant General Arrangement drawings for details of the tower layout, elements and fixings used on the structure. Refer to the relevant Method Statement and Risk Assessment for the assembly and erection sequence of the structure.

The vast majority of structural bolts on FLI's structures are designed as non-preloaded bolts (ordinary/un-torqued). These guidance notes are only appropriate for non-preloaded bolts.

High Strength Friction bolts (HSFG, Non-Slip) bolts are occasionally utilised. Where HSFG bolts are used, these guidance notes do not apply and a tightening method appropriate to the bolt type must be formulated and used.

2.0 BOLT CONFIGURATION

Bolt assemblies supplied by FLI Structures typically comprise a Bolt (Grade 8.8 spun galvanised to BS EN ISO 10684:2004), Nut and Flat Washer for use under the nut. Spring washers are not supplied, nor desired. Bolts are supplied "dry", i.e. not lubricated. Any quoted torques apply to bolts in this condition.

All bolts shall be fitted such that the nut is underneath. This ensures that if for any reason a nut worked loose the bolt would remain in place. The only exception is where the bolts can only be fitted the other way around.

U-Bolts and N-Bolts are typically Grade 4.6. and comprise the shaft, and one washer and 2 nuts per threaded end, the second nut being used as a lock nut.

Special bolts, fixings and configurations are utilised from time to time, such as Hardlock Nuts and PAL nuts, as detailed on the structure specific General Arrangement Drawing. Where special fixings are supplied, appropriate tightening methods must be used.

3.0 BOLT LENGTH

Bolts have been selected to give a minimum thread projection in accordance with the National Structural Steelwork Specification 4th Edition, pg 41, clause 6.1.4, which states:

'Bolt length shall be chosen such that, after tightening at least one clear thread projects past the nut'

It is therefore important that the correct bolts are used in each connection. FLI's assembly drawings give details of which nuts and bolts are to be used and the quantities of each size required are supplied in individual labelled bags with the tower.

4.0 CORROSION PROTECTION

Bolts and other structural fasteners are typically spun galvanised and as such have an average coating thickness of 50µm (For more information, also see ISO 10684:2004). This may equate to a lower design life than the structure and so the bolts on the structure may have to be replaced, depending on the actual corrosion rate. This can be controlled via the inspection regime.

5.0 BOLT TIGHTENING – ORDINARY BOLTS (NON-PRELOADED)

- Component parts should be identified & collated, using the packing list.
- Components should be assembled, in accordance with the assembly drawings, typically on blocks on a level surface.
- A dimensional check of the assembly should be carried out, before tightening the bolts.

5.1 1st Stage Bolt tightening

- The bolts should be **fully tightened** using an impact driver and spanner or 2 spanners.

For structural bolts designed as ordinary, non-preloaded bolts the following guidance applies.

Initial tightening shall be by hand to the following method.

"Bolts shall be made "snug tight" being that tightness achievable by the effort of one man using a normal sized spanner without an extension arm, and can be set as the point at which a percussion wrench starts hammering." Ref Eurocode standard for Execution of Steel Structures BS EN 1090-2 Cl 8.3 note 2:

- **Caution must be exercised if using percussion wrenches.** Many modern models can apply well in excess of 250Nm, which will certainly overstress bolts and strip threads. It is essential that the correct model of percussion wrench is chosen and that it is suitably calibrated for the task at hand. **If calibration of percussion wrenches is not possible, then they shall not be used.**
- The following table provides the recommended torques to be applied by a percussion wrenches.

Percussion Wrench **Recommended Torque Settings**		
Bolt Size	Bolt Grade	
	4.6	**8.8 & 10.8**
	Torque Nm	
M12	30	**65**
M16	60	**135**
M20	110	**135**
M24	130	**135**
M30	180	**250**
M36	250	**250**
M42	250	**250**

- A table of Maximum permissible torque applied by percussion wrenches is shown in the residual hazards part of this document

5.2 2nd stage Bolt Tightness Check

- 2nd stage Bolt tightness checks shall be done after a minimum of 1 hour, although the longer this can be delayed, the better, ideally 5 days.
- All bolts should undergo the 2nd Stage bolt tightness check and marked with a **RED** marker on the bolt head by the checker.
- Pre-assembled bolts have a **BLACK** mark to indicate they have been checked in the Works (Ref FLI QP15). Thus, all bolts shall either have a **RED** mark to indicate a site assembly and tightness check or a **BLACK** and a **RED** mark to indicate a works and site tightness check.

2nd Stage tightening shall either be by hand as describe above, or if desired, with a torque wrench where the following guidance values may be appropriate.

2nd Stage Tightness Checks **Torque Wrench Settings**		
Bolt Size	Bolt Grade	
	4.6	**8.8 & 10.8**
	Torque Nm	
M12	30	**65**
M16	60	**90**
M20	110	**110**
M24	130	**130**
M30	160	**160**
M36	200	**200**
M42	240	**240**

These values have been set to mimic the approximate hand tightening torque as found in the BCSA/SCI book: P212: Joints in Steel Construction: Simple Connections in Table H.62, taking hand tightness as 250N = 25kg on end of the Podger spanner.

6.0 MAINTENANCE TIGHTNESS CHECKS

If, during maintenance operations, bolts are to be checked with a torque wrench to validate tightness, then the following values may be appropriate.

Maintenance Tightness Checks **Torque Wrench Settings**		
Bolt Size	Bolt Grade	
	4.6	**8.8 & 10.8**
	Torque Nm	
M12	30	**60**
M16	60	**80**
M20	100	**100**
M24	115	**115**
M30	145	**145**
M36	180	**180**
M42	210	**210**

These values have been set at approximately 90% of the hand tightening torque. This is intended to avoid spurious reports of loose bolts, while still being meaningful.

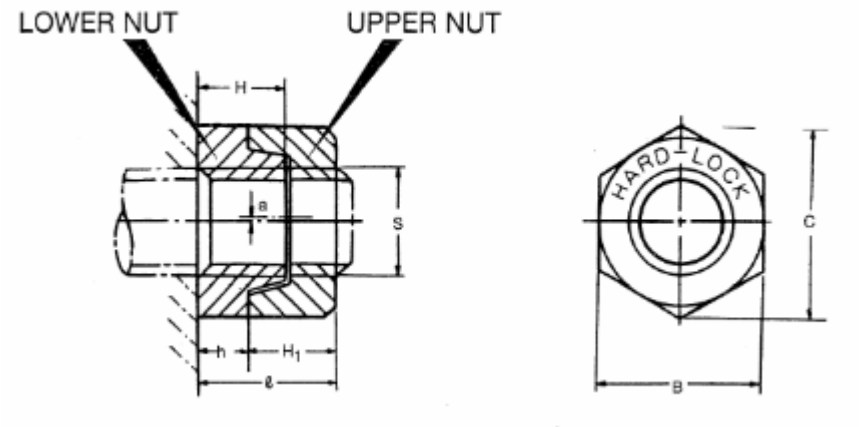
7.0 HARDLOCK NUTS - INSTALLATION AND TIGHTENING

Hardlock nuts require specific installation methods to be followed.

Providing the guidance for the installation of these nuts are followed, there is no requirement for a final check on the structural bolt positions. This is because the methods of installation in this document require tightness checks to be completed during the installation process.

Hardlock nuts consist of two separate nuts which when tightened correctly provide an effective locking to any structural fastener.

The nuts are supplied loose and each assembly consists of two separate items. The lower nut has an eccentric cone, which is proud of one of the faces of the nut. The upper nut has a concentric recess machined in one of its faces.



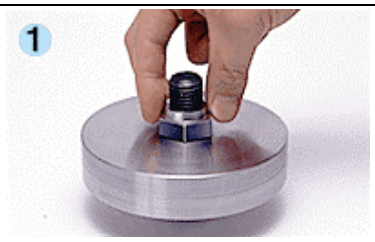
Whilst the tower modules are on the ground, fit the bolt through the parts to be connected and then fit a standard flat washer and the Hard Lock lower nut. It is essential that the lower nut be fitted with the smooth face flush to the washer and fully tightened. Tighten using the 1st stage tightening guidance given above.

Once the tower has been lifted into position and at least 1 hour after 1st stage tightening, the lower nut should be checked for tightness, using the 2nd stage tightening guidance given above.

Then fit the upper nut on the assembly ensuring that the recess in the upper nut will fit over the cone in the lower nut. Using a torque wrench tighten the upper nut to at least the minimum seating torque shown in Table 1.

Pre-assembled tower modules will not have the upper nut fitted when delivered to site. These should be fitted once the tower has been lifted into position and the lower nuts have been checked as above.

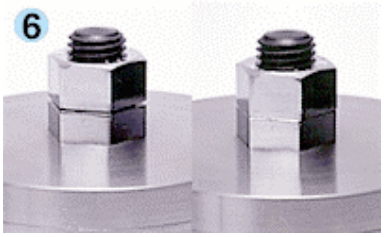
Note: Providing the torque settings have been achieved, there is no need tighten until the gap between upper and lower nuts is fully closed or to make the flat faces of the nuts to coincide.

	
Pass the bolt through the materials to be attached and screw the lower (convex) nut onto the bolt.	Fully tighten using 1st stage tightening guidance above

At this point, the lower nut has exactly the same strength as a general-purpose nut.

Next, screw the upper (concave) nut onto the bolt by hand.

After tightening the upper nut by hand, use a torque wrench to tighten to at least the minimum torque setting given in the Table.



There may be gaps between the upper and lower nuts at this time and nut faces may not coincide. This is perfectly acceptable.

Size	Upper Nut Min Seating Torque Nm	Upper Nut Max Seating Torque Nm
M12	27	39
M16	70	100
M20	120	200
M24	160	300

Table 1: Seating Torques (This Table is for SS400 grade nuts only).

Maintenance Tightness Check on Hardlock Nuts must appropriate to the installation method. Excessive torques must not be applied to the upper nut.

8.0 PAL NUTS – INSTALLATION AND TIGHTENING

PAL nuts require specific installation methods to be followed.

Providing the guidance for the installation of these nuts are followed, there is no requirement for a final check on the structural bolt positions. This is because the methods of installation in this document require tightness checks to be completed during the installation process

PAL nuts are fitted on top of a standard nut as a visual check that 2nd stage tightening has been completed. Due to its design there is no need for either a flat or spring washer beneath the face of the standard nut.

Whilst the tower modules are on the ground, fit the bolt through the parts to be connected, then fit a standard nut and tighten using the 1st stage tightening guidance given above.

Once the tower has been lifted into position, providing a minimum period of one hour has passed since the initial tightening, the standard nut on each assembly should be checked for tightness, using the 2nd stage tightening guidance given above.

Fit the PAL nut onto the assembly and tighten using an open-ended spanner, until tight plus one half turn.

One Half turn of the Pal Nut is best confirmed by match marking the nut and Pal nut on opposite faces and tightening until the lines are coincident.

Pre-assembled tower modules will not have the PAL nut fitted when delivered to site. These should be fitted once the tower has been lifted into position and the standard nuts have been checked as above.

Maintenance Tightness Check on PAL Nuts must be appropriate to the installation method. Excessive torques must not be applied to the PAL nut.

9.0 **DESIGNERS STATEMENT OF RESIDUAL HAZARDS**

<table>
<tr><th>Design Residual Hazard</th><th>Description</th><th>Activity</th></tr>
<tr><td>Loose Bolts</td><td colspan="2">Bolts may remain or become loose if not adequately tightened during installation. Adequate and appropriate control measures must be in place to ensure connections are tightened correctly</td><td>Installation
Maintenance</td></tr>
<tr><td>Stripped threads or rupture of bolts.</td><td>Application of excessive force can lead to stripping of bolt threads or failure of the bolt.
In particular, great care must be taken with Percussion Wrenches.
Maximum permissible values are listed in the adjacent table.</td><td>
<table>
<tr><th colspan="3">Percussion Wrench
Maximum Permissible Torque Settings</th></tr>
<tr><td rowspan="3">Bolt Size</td><td colspan="2">Bolt Grade</td></tr>
<tr><td>4.6</td><td>8.8 & 10.8</td></tr>
<tr><td colspan="2">Torque Nm</td></tr>
<tr><td>M12</td><td>30</td><td>65</td></tr>
<tr><td>M16</td><td>60</td><td>110</td></tr>
<tr><td>M20</td><td>110</td><td>210</td></tr>
<tr><td>M24</td><td>130</td><td>300</td></tr>
<tr><td>M30</td><td>180</td><td>450</td></tr>
<tr><td>M36</td><td>280</td><td>700</td></tr>
<tr><td>M42</td><td>400</td><td>1000</td></tr>
</table>
</td><td>Installation
Maintenance</td></tr>
<tr><td>Failure of locking mechanism</td><td colspan="2">Incorrect tightening of locking nuts or special fasteners can lead to failure of the locking function. Appropriate tightening techniques must be used.</td><td>Installation
Maintenance</td></tr>
</table>

A full risk assessment or each of the relevant identified hazards above needs to be completed by the inspector and/or maintainer.