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Operation & Maintenance Manual

General FLI Structures Products

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1.0

INTRODUCTION

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

This document contains general information required for the safe operation and maintenance of General FLI Structures Products. 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 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
Entrapment by hinged or rotating parts	During assembly of hinged or rotating items, body parts (fingers, arms, legs) can become trapped between the parts as they hinge into position.	Installation Dismantling
Separation of hinged or rotating parts during lifting	During installation, hinged or rotating items may separate during lifting. It is important that the hinged items are secured using an appropriate method. Refer to installation guidance in the relevant FLI document.	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 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 (lack of anti-climb measures) 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
Installation of assembled modules – damage due to leg buckling	For some tower modules, when standing the sections up (i.e. when moving from the horizontal position to the vertical) the legs can buckle if no appropriate temporary bracing is employed.	Installation Dismantling
Installation of assembled modules – dangers from loose bracing	For some towers, the bottom brace of every module attaches to the module below it. For these towers, during lifting of completed sections, the bottom brace can be damaged if not restrained from rotation.	Installation Dismantling
Connection of modules – rotation of braces	In some tower modules adjacent braces in the same face are fixed through a common bolthole. During installation this requires the bolt fixing the braces to be removed and reinstalled. Insufficient care can result in braces rotating and causing injury or damage to elements.	Installation Dismantling

Design Residual Hazard	Description	Activity
Installation of multi piece monopoles – damage due to incorrect shaft orientation	Some monopoles will be delivered to site in two or more pieces. Misalignment of mating faces can result in damage to the shafts.	Installation Dismantling
Installation of multi piece monopoles – separation during lifting	Monopole shafts can separate during lifting if inadequately held together. This may result in damage to elements and serious injury to nearby persons.	Installation Dismantling
Use of incomplete ladder/climbing face during installation	Climbing ladders or access equipment before a “safe to climb” certificate has been issued can result in serious injury or death.	Installation Dismantling
Difficult foot holds during installation	During installation of tower sections it may be necessary to stand on the inclined bracings. Falls or injury can result if incorrect climbing techniques are employed.	Installation Dismantling
Lightning strikes	Serious injury can result if structures are climbed during electrical storms or if the earth lugs provided at the base of monopoles or on each leg for towers are not connected to the earthing system.	Installation Maintenance Dismantling
Use of inappropriate foundation designs	It is the responsibility of the foundation designer to ensure that appropriate base sizes have been designed for above-ground structures. Refer to the relevant drawings for more information on the unfactored base forces and foundation connections.	Installation
Ice damage to tower uprights	If tower uprights are manufactured from tubular sections they could be damaged by trapped water freezing at low temperatures if there is no provision for drainage and regular inspection.	Installation Maintenance
Collapse during dismantling	Structures can collapse unexpectedly or dismantled in an inappropriate manner. A competent person must always prepare a suitable method for dismantling.	Dismantling

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

3.0 **INSTALLATION GUIDANCE**

Refer to the relevant General Arrangement drawings for details of the tower layout, elements and fixings used on the structure.

3.1 **Assembly and Erection**

The assembly and lifting method and sequence will vary between structure types, equipment availability and site constraints.

When planning the structure assembly and erection the installer must consider the health and safety of the workforce as his first priority. Good practice in this regard is to follow the Working at Height Hierarchy of control:

- a. Avoid working at height, e.g. pre-assemble as much as possible at ground level.
- b. Prevent falls using appropriate access equipment such as Mobile Elevated Work Platforms (Cherry pickers) or rope access techniques.
- c. Reduce the distance and consequences of a fall should one occur, e.g. use fall arrest systems or catch nets.

Practicality and efficiency should also be considered. Where structurally possible, lifting structures in one piece is preferable to multiple lifts or as a last resort, derrick build. However the cranes available and the site constraints will also influence the assembly and erection methods.

Prior to lifting structures onto the foundation or grillage, the position of the Hold Down Bolts or base stubs should be checked against the layout of the structure base plates or legs. Any discrepancy shall be noted and clarity sought.

3.2 **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 and secondary structural members so as 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

3.3 **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 structure specific General Arrangement Drawing. Where special fixings are supplied, appropriate tightening methods must be used.

3.4

Bolt Tightening – Ordinary Bolts (non-preloaded)

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

It is important that the correct fixings are used in each connection. FLI's assembly drawings, which are delivered with the tower, give details of the nuts and bolts that are to be used and the quantities of each size required. The vast majority of structural bolts are to be designed as ordinary, non-preloaded bolts (un-torqued). The bolt tightening method shall be in accordance with the standard for the Execution of Steel Structures BS EN 1090-2 Cl 8.3 note 2:

“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.”

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 1st table sets out the bolt torques that are appropriate during the 2nd stage tightness checks to be undertaken as part of the installation checks and a minimum 1 hour after initial tightening.

The 2nd table sets out the bolt torques that are appropriate during maintenance tightness checks. These have been calibrated to avoid spurious reports of loose bolts.

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

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

B: Bolt tightness should be checked no sooner than 1 hr after initial tightening.

Note that natural material creep will result in loss of bolt tension (and so tightness); however the vast majority of the loss occurs in the first hours after tightening. This is why bolt tightness checks should be delayed as long as possible. However bolt tightness checks should be performed before the installation crews demobilise from site. It is good practice to mark bolts after the tightening and checking operations. This can be done using a permanent marker, so some other suitable method.

3.5 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 STATEMENT

BS8100 recommends that inspections for Class A structures (towers, monopoles, grillages, etc.) be completed at intervals no greater than 2 years. Fall Arrest systems should be inspected at least once a year.

As a minimum, the following items are to be examined:

Item	Description
Ground Works and Foundation	<p>Any concrete foundation shall be checked for general deterioration. This may include cracking, spalling and discolouration.</p> <p>The ground around the foundation shall be checked to ensure there is no visible movement, erosion or subsidence. Any drainage or surface water problems in the vicinity of the foundation should be noted as these can affect the stability of the foundations.</p> <p>The interface between towers and their foundations should be checked to ensure the drainage paths for the uprights are clear.</p>
Earthing	<p>The earthing system must be checked for electrical resistance in accordance with the original customer specification.</p>
Tower Structure and ladder	<p>An ascent of towers shall be made to inspect all members and connections for corrosion and any form of distress, e.g. bent or fractured members.</p>
General Bolt Tightness	<p>A 5% representative sample of all bolts shall be tested for tightness.</p> <p>Tightness checks need to be appropriate to the type of bolt.</p> <p>If there are any problems, check another 5%. If further problems are encountered all bolts in similar locations must be checked and tightened.</p>
Grillage	<p>Members and connections shall be inspected for corrosion and any form of distress, e.g. bent or fractured members.</p> <p>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.</p> <p>A 5% representative sample of all ancillary bolts (i.e. hand railing etc.) shall be tested for tightness, and if there are any problems, check another 5% of remaining sample. If further problems are encountered</p>

	all bolts in similar locations must be checked and tightened.
Fall Arrest Systems	The fall arrest system should be checked in accordance with the OEM installation and maintenance statement.
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.
Antennas and feeders	Equipment and power or other feed cable mountings should be checked for any loose fittings. Any obvious damage to equipment should be reported.

4.1 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.