

Risk management

Tower cranes collapsing on construction sites

A guide to loss prevention



Loss prevention

In recent years, a number of tower cranes have collapsed on construction sites causing serious accidents involving personal injury, significant property damage and business interruption.

The hazards which increase the risk of a collapse event are numerous and can include poorly designed foundations, operating in high winds (including impaired free-slewing arrangements), lack of maintenance, inexperienced crane operators and supervisors, and underrated crane capacity. Many incidents are as a result of documented safety procedures not being followed.

This document aims to provide a guide to the prevention of collapse events involving tower cranes. Whilst there are different types of tower crane, and the specific operating instructions for a particular crane should be referred to, many of the loss prevention principles are common.

A list of common terms and definitions is located at the end of this document.

Further industry best practice guidance is included at the end of this document, and the reader is strongly recommended to refer to BS 7121, CIRIA guide C703 and CPA guidance information.

Key components in preventing the collapse of tower cranes include the following.

Hired Crane (hired and managed)	Contract Lift (fully contracted)
<p>The employing organisation must:</p> <ul style="list-style-type: none">- Carry out all work in accordance with BS7121- Supply the Appointed Person- Plan the lift and operate a safe system of work- Ensure that the crane hired is of a suitable type, capacity and configuration- Check the credentials of the crane hire company and certification supplied	<p>The employing organisation should specify:</p> <ul style="list-style-type: none">- That all work is to be undertaken in accordance with BS7121- That the crane owner/contractor is to supply appropriately maintained and certified equipment and Competent Persons- What information and/or services will be provided to the contractor by the employing organisation
<p>The crane owner has a duty to:</p> <ul style="list-style-type: none">- Provide the loads imposed by the crane to assist with the design of a suitable support- Provide a crane that is properly erected, maintained, tested and certified- Provide a competent driver (where required)	<p>The crane owner/contractor is responsible for:</p> <ul style="list-style-type: none">- Supplying the appropriately maintained and certified equipment and Competent Persons (e.g. AP, driver etc)- Planning and documenting the lifting operations and ensuring that a safe system of work is in place- Organisation and control of lifting operations

Management and planning

Many tower crane collapses can be traced back to poor management and planning of tower crane operations. The following elements are key to ensuring lifting is carried out safely and without incident.

Safe system of work: a safe system of work should be in place for all lifting operations and should include planning of the operation, selection of a suitable crane and equipment, maintenance of the crane and equipment, preparation of the site, provision of properly trained and competent supervisory personnel, ensuring all test certificates and thorough examination reports are available, preventing unauthorised movement or use of the crane, provision for the safety of all those involved or affected by the operation. The safe system of work must be embodied within a Lifting Plan.

Selection and duties of personnel: all those involved in a lifting operation must be competent, adequately trained and aware of their duties. The duties of crane drivers, slingers, signallers, maintenance personnel etc, is detailed in BS7121-1. All crane drivers should hold a CPCS card.

Appointed Person (AP): the AP has overall control of the lifting operations and their duties should include:

- assessment of the construction site environment and lifting operation requirements including planning, choice of crane and equipment, and liaison with other parties affected by the lift
- ensuring inspection and maintenance has been carried out
- organisation and control of all lifting operations
- briefing the Crane Supervisor on the contents of the method statement and Lifting Plan
- ensuring there is an effective procedure for reporting defects and incidents and taking any necessary corrective action

Some of the duties, but not the responsibilities, may be delegated for simple lifts. The AP should consult with other experts including temporary works engineers and crane suppliers.

Crane maintenance:

the crane should be in a satisfactory operating condition at all times. Planned maintenance and prescribed safety checks should be undertaken with test certificates and documentation in place. Detailed requirements and checklists are included in BS7121-2-5 and both LOLER and PUWER Regulations as well as detailed guides produced by the CPA, including TCIG-0801.

Pre-use checks, daily, weekly and in-service inspections/maintenance checks are essential and need to be recorded. Key aspects to check during maintenance include, but are not limited to:

- general condition of structures (e.g. fatigue cracks), fastenings, ties and machinery
 - operation of alarms, warning lights, indicators, motion limiters and cab accessories
 - brakes, including the weathervaning mechanism
 - slewing mechanism, control gear, safety devices, cables and pulley block
 - documentation and warning signs are present, etc.
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Thorough examinations: Thorough examinations (TEs) need to be carried out at: specified intervals, after installation, after major alterations or repair or after exceptional circumstances affecting the safety of the crane. LOLER specifies maximum intervals between TEs are six months for tower cranes that lift people and twelve months for tower cranes that lift goods only. It is, however, good practice to set the maximum interval for all tower cranes on construction sites at six months due to their use in:

- potential emergencies; to lift injured or trapped site personnel from buildings or shafts, etc
- frequently lifting loads above or near people (site personnel and members of the public)
- intense and rugged working environments

TEs needs to be undertaken by a Competent Person and to a defined scope (see TCIG 0801 and 8.7.2 of BS 7121-2-5 for a detailed list of components to be included).

Contract lift vs crane hire: an organisation that requires the use of a tower crane and does not have its own craneage has two options - hiring a crane (Hired Crane) or employing a contractor to carry out lifting operations (Contract Lift). If an individual or organisation does not have expertise in lifting operations, they should not hire cranes but should opt for the contract lift option.

Insurance arrangements should be clarified. A summary of the options is included in the following table.

A useful best practice guide and pro formas on producing a risk assessment and method statement for a contract lift is available from the CPA Crane Interest Group: www.cpa.uk.net

Risk assessment and method statement: an essential element of any crane operation is the production of a risk assessment and method statement. The risk assessment should be carried out by the AP and identify the hazards and risks associated with the lifting operation. Reference should be made to the overall site risk assessments included in the CDM Construction Phase Plan. The AP should ensure that a full method statement is prepared, detailing the safe system of work and control measures for the lifting operation. A Permit to Lift is a useful mechanism to ensure all pre-lift checks are undertaken.

Crane selection and access: the choice of a suitable tower crane is governed by a number of factors, including: the characteristics of the loads to be lifted (weight and dimensions), radii, heights of lifts, areas of movement, frequency and types of lifting operations, length of time on site, construction site configuration and space available for access, erection, operation and dismantling.

Checklists: the management, planning and execution of a crane lifting operation need to take into account many aspects. Consequently, it is recommended that the use of checklists and pro formas are employed to ensure no aspect is left unaddressed. These may include, but not limited to: key elements of the safe system of work, the load and the lift, the location, specifying and operating teams, the crane, the lifting gear and any temporary works. Sample checklists are included in C703. Periodic inspection checklists for a tower crane should be completed (see BS 7121-2-5 and CPA document TCIG 0801).



Siting of cranes

The siting of a tower crane to ensure its stability needs to be carefully considered by the AP, taking into account a number of aspects, including:

Alterations and construction work: any alterations, including increasing the height of the tower. Construction activities required near to the base or any ties to high-rise structures.

Access, radius and height: sufficient room for the construction of the foundation and the installation and removal of the crane. Requirements for the maximum load, radius and hook height.

Vaults, basements or underground services: the location of underground services and adjacent structures on which load could be imposed by the crane foundation, e.g. retained basements.

Wind: the effect of wind both in and out of service for a particular location, e.g. cliff tops. Placing tower cranes in free-slew mode when out of service may avoid collapse events.

Proximity hazards: these include overhead electrical cables, nearby structures, other cranes, railways and flight paths. The appropriate authority should be consulted if any part of the crane cannot be kept clear of such hazards or areas. Restrictions on oversailing should be applied. The sequence of crane movements should be planned by the Crane Coordinator to avoid collisions between other cranes and equipment.

Tower crane foundations and support

A suitable crane standing, support or foundation base is essential for the stability and safe operation of the crane. The following aspects are key to ensuring adequate support is provided.

Crane standing or support conditions: the AP should ensure that the ground, or any means of support, can sustain the loads imposed by the crane. This should be undertaken by a Competent Person and use the loading data provided by the crane manufacturer and include the most severe combined effects of the following:

- the dead weight of the crane including any counterweight, ballast or foundation
- the dead weight of the load with the addition of accessories used for lifting
- dynamic forces caused by movement of the crane
- loads imposed by wind and ice

(Note: for guidance on suitable support and controls for mobile self-erecting tower cranes, see our guide to loss prevention entitled 'Mobile cranes overturning on construction sites' (available at www.hsbeil.com) and CPA guidance on the Safe use of Self Erecting Tower Cranes.)

Crane ties: where cranes are tied into a building, the supports should be included as part of the design. This will involve liaison between the Competent Person and the permanent works designers. Ties should be inspected before the crane goes into service to confirm they have been installed to the design specification, and an inspection report produced. Following the inspection, a permit to erect should be issued by the responsible person. Sample reports and completion certificates are provided in BS 7121-2-5.

Expendable base: the minimum dimensions for an expendable base block should be provided by the crane manufacturer. Given these dimensions, along with the load data, a Competent Person should design a suitable foundation so as to ensure that the ground bearing capacity is not exceeded.

Rail tracks: rail tracks should be made of suitable material, not be used for storage and be fenced off to prevent unauthorised access. The tracks should not be welded or subject to heating. The end stops should be bolted or pinned and be positioned such that the crane makes contact on each stop simultaneously. The end stops should also be either buffered or shock absorbing. Rail clamps should be provided to prevent the crane rolling along the track in storm conditions or whenever it is out of service.

Special bases: in some instances, special base arrangements may be required for example fixing to structural steelwork on cruciforms or grillages. The AP should ensure that the base is designed appropriately and verified by a third party Competent Person, and constructed in accordance with the design.

Loading, erection, climbing and dismantling

Poorly controlled loading, erection, climbing and dismantling operations can lead to tower crane collapse events. These aspects need to be scrutinised and managed by Competent Persons.

Load components: tower cranes can collapse as a result of lifting excessive loads, overreaching, high winds and swinging loads, which increase the load radius and overturning moment. Control measures include only lifting pre-agreed weights, working within the defined radius, monitoring and ceasing work during high winds, and lifting loads gently and smoothly to avoid loads swinging. Loads should not be dragged along the ground and side loading of the jib should be avoided. A rated capacity indicator/limiter should be employed.

Erection and dismantling: the erection and dismantling of a tower crane should be the subject of a specific risk assessment and method statement. The manufacturers' instructions must be followed to ensure stability throughout the process and that structural and mechanical parts are not subject to excessive loading. Particular attention should be paid to interim stages where out of balance forces from the jib or counterweights could lead to collapse.

Floor climbing: floor climbing cranes are employed on tall buildings using hydraulics and the permanent structure for support. The arrangements are specialised and need to be carefully planned and executed by Competent Persons. Liaison with the permanent works designer is essential. Full details and guidance are included in BS 7121-5 and CPA TCIG 1101.

Legislation

Statutory requirements: there are many statutory requirements which apply to lifting operations. The following are the main references:

- The Health and Safety at Work Act 1974
- The Construction (Design and Management) Regulations 1994 (as amended)
- The Management of Health and Safety at Work Regulations 1999
- The Lifting Operations and Lifting Equipment Regulations 1998 (LOLER)
- The Provision and Use of Work Equipment Regulations 1998 (PUWER)
- The Supply of Machinery (Safety) Regulations 2008 (as amended)

In addition, a list of references and guidance is included at the end of this document.



The table below provides a summary of typical hazards and suitable control measures to mitigate the risk of collapse or failure of a tower crane. The table does not necessarily include all hazards that may be present, which should be identified by a site specific risk assessment.

Collapse hazard	Controls to mitigate the risk
Failure of the ground and/or foundation base or support	
Incorrect support or foundation base specified	The support or foundation base should be designed by a Competent Person taking into account load and soil data. An audit trail should be included in each crane maintenance log which details the support design, along with confirmation by third parties as to its suitability.
Support or foundation base incorrectly constructed	The audit trail for the support design should include a sign-off document that confirms the support or foundation base has been constructed as per the design.
Management and planning failures	
Inexperienced supervisors and crane operator	Ensure only competent, trained persons are employed (see BS 7121-1). Consider a Contract Lift if competence of supervisors is in doubt.
Unclear roles and responsibilities	Ensure key positions are established and individuals appointed by letter detailing their roles and responsibilities.
Uncontrolled lifting operations	Ensure all lifting operations are subject to a Lifting Plan including a risk assessment and method statement and a Permit to Lift.
Collision	Ensure that all lifting operations are planned with all proximity hazards identified. If multiple tower cranes are overlapping, then anti-collision devices should be installed.
Overloading	
Load too heavy	Ensure the load to be lifted is not greater than allowed for in the planning. The rated capacity limiter/indicator should be maintained in good order.
High wind loading	Establish site wind speed limits (red/amber/green). Use an anemometer to monitor in-service wind speeds and ensure maximum speed for crane configuration is not exceeded. Monitor weather forecasts and ensure the slew brake is disengaged during periods when the crane is non-operational (see HSE guidance www.hse.gov.uk/safetybulletins/luffing-jib-tower-cranes.htm).
Mechanical failure	
Poorly maintained crane/component fatigue failure	Ensure crane is regularly maintained in accordance with the LOLER and PUWER Regulations and thorough examinations performed.

Case study

Two construction firms were successfully prosecuted after a tower crane collapsed onto a city centre apartment block, resulting in the crane driver suffering multiple injuries. The tower crane was being used as part of a multi-million pound project to build a new hotel and apartment blocks.

The HSE investigation into the incident found that the crane's foundation could not cope with the forces generated by the crane. During the construction of the foundation, both the principal contractor and the structural engineering company agreed to cut away essential steel reinforcement bars from the four concrete foundation piles to allow the crane feet to sit on them.

The HSE identified serious failings by both parties as having been responsible for the collapse. The structural engineering company had no previous experience of designing the type of



crane foundation used and, likewise, the principal contractor's employees had no experience of building one. Neither company did enough to check what the result would be of cutting away the essential steel reinforcement.

Designers should be familiar with industry accepted guidance and strictly adhere to design information supplied by tower crane providers. The role of the principal contractor is also crucial in managing the design process.

Common terms and definitions

Lifting Plan: a document providing full details of a crane lift including responsibilities, loads/safe working loads, crane type, lifting accessories, sequence of operations, hand signals and radios, wind speed policy, checklists, sketches, a risk assessment and method statement, etc. This is a legal requirement of Regulation 8 of the LOLER Regulations and should be formulated by a Competent Person.

Permit to Lift: a formal process recording checks and approvals prior to confirming a lift may proceed.

Thorough Examination: detailed examination by a Competent Person to determine if a crane is safe to take into use or continue in use. This is in addition to the maintenance regime.

Appointed Person (AP): a key person with the training, practical and theoretical knowledge and experience

required to plan and manage a lifting operation.

Crane Supervisor: person who controls the lifting operation and ensures that it is carried out in accordance with the AP's safe system of work.

Crane Coordinator: person who plans and directs the sequence of operations of cranes to ensure that they do not collide with other cranes, loads and other equipment.

Crane Operator: person who is operating the crane for the purpose of positioning loads or erection of the crane.

Slinger: person responsible for attaching and detaching the load to and from the crane and for the correct selection and use of lifting accessories.

Signaller: person responsible for directing the crane driver to ensure safe movement of the crane and load.

References and Guidance

- BS 7121-1:2006 - Code of practice for safe use of cranes (www.bsigroup.com)
- BS 7121-2-5:2012 - Code of practice for the safe use of cranes - Inspection, maintenance and thorough examination - Tower cranes (www.bsigroup.com)
- BS 7121-5 :2006 Code of practice for safe use of cranes - Tower Cranes (www.bsigroup.com)
- CIRIA Publication C703:2003 - Crane stability on site (www.ciria.org)
- CPA / Crane Interest Group - Best Practice Guide for Risk Assessment and Method Statement for a Contract Lift: 2012 (www.cpa.uk.net)
- CPA / Tower Crane Interest Group - Maintenance, Inspection and Thorough Examination of Tower Cranes TCIG 0801 (www.cpa.uk.net)
- CPA / Tower Crane Interest Group - Safe Use of Self Erecting Tower Cranes: 2010 (www.cpa.uk.net)
- CPA / Tower Crane Interest Group - The Climbing of Tower Cranes TCIG 1101: 2011 (www.cpa.uk.net)

Disclaimer: The guidance in this document refers to industry best practice loss control advice. Adoption of the advice contained within this document does not imply compliance with industry, statutory or HSEI guidelines, nor does it guarantee that related losses will not occur.

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