Mobile cranes overturning on construction sites

A guide to loss prevention
Each year, a number of mobile cranes overturn on construction sites causing serious accidents involving personal injury, significant property damage and potential business interruption claims. Most incidents are as a result of inadequate planning, unclear responsibilities or unsafe use.

The hazards which increase the risk of an overturning event are many and include unstable working platforms, subsurface voids, high winds, poor maintenance, inexperienced crane operators and supervisors, excessive loads, underrated crane capacity and poor use of outriggers and bearing plates, etc.

A guide to loss prevention

This document aims to provide a guide to the prevention of overturning events involving mobile cranes. There are different types of mobile crane and the specific operating instructions for a particular crane should be referred to. However, many of the loss prevention principles are common. This guide does not attempt to cover the design of cranes, nor does it cover all aspects of lifting operations (such as marine operations, for example).

Further industry best practice guidance is included towards the end of this document and the reader is strongly recommended to refer to BS 7121 and the CIRIA guide C703 in particular when planning mobile crane operations.

Common terms and definitions

Mobile crane: a lorry-mounted, telescopic crane provided with rubber tyres and outriggers. Capacities and types vary and include rough terrain and all-terrain models. A mobile crane can travel to site on the public highway and generally be positioned, rigged and in use promptly. They are generally used for short duration operations and where mobility around or on/off site is important.

Crawler crane: a crane mounted on a tracked chassis. Lifting capacities are typically greater than for mobile cranes and movement around site is possible fully rigged. Crawler cranes are generally employed for longer durations and for undertaking routine lifts and movements over relatively short distances.

Lifting plan: a document providing full details of a crane lift including responsibilities, loads/safe working loads, crane type, ground conditions/working platform suitability, lifting accessories, sequence of operations, hand signals and radios, wind speed policy, checklists, sketches, a risk assessment and method statement, etc.

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

Appointed Person: a key person with the training, practical and theoretical knowledge and experience required to plan and manage a lifting operation.

Crane supervisor: Appointed Person who controls the lifting operation and ensures that it is carried out in accordance with the Appointed Person’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.

Working platform: temporary geotechnical structure providing a stable working surface for mobile cranes, piling rigs and other heavy construction equipment.

Working Platform Certificate: a certificate which confirms the working platform has been properly constructed in accordance with the design, and that it will be adequately maintained to ensure its ongoing integrity. The certificate requires the signature of the main contractor on site and must be handed to the Appointed Person before lifting work commences. The certificate introduces a system for defining specific responsibilities, increasing safety awareness and highlighting the importance of maintaining the platform in good condition.

Key components in preventing the overturning of mobile cranes include:

Management and planning

Many overturning events can be traced back to poor management and planning of the lift. The following elements are key to ensuring a lift is carried out safely and without incident.

1. 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 could usefully be embodied within a lifting plan.

2. 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 and maintenance personnel etc., is detailed in BS7121-1. All crane drivers should hold a CPCS card.
3. Appointed Person
The Appointed Person has overall control of the lifting operation and their duties should include:
- assessment of the lifting operation 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 Appointed Person should consult with other experts including temporary works engineers and crane suppliers.

4. Crane maintenance
The crane should be in a satisfactory operating order at all times. Planned maintenance should be undertaken and thorough examinations performed, with test certificates and documentation in place. Detailed requirements are included in BS7121 and the LOLER and PUWER Regulations.

5. Contract lift vs crane hire
An organisation that requires a load to be moved, and does not have its own craneage, has two options: hiring a crane (Hired Crane) or employing a contractor to carry out the lifting operation (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.

<table>
<thead>
<tr>
<th>Hired Crane (hired and managed)</th>
<th>Contract Lift (fully contracted)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The employing organisation must do the following:</strong></td>
<td><strong>The employing organisation should specify the following:</strong></td>
</tr>
<tr>
<td>- Carry out all work in accordance with BS7121</td>
<td>- That all work is to be undertaken in accordance with BS7121</td>
</tr>
<tr>
<td>- Supply the Appointed Person</td>
<td>- That the crane owner (contractor) is to supply appropriately maintained/test/certified equipment and any competent persons required (including driver appointed persons, etc)</td>
</tr>
<tr>
<td>- Plan the lift and operate a safe system of work</td>
<td>- What information and/or services will be provided to the crane owner (contractor) by the employing organisation</td>
</tr>
<tr>
<td>- Ensure that the crane hired is of a suitable type and capacity</td>
<td>- Provide suitable working platform</td>
</tr>
<tr>
<td>- Ensure suitability of working platform</td>
<td></td>
</tr>
<tr>
<td>- Check the credentials of the crane hire company and certification supplied</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The crane owner has a duty to:</th>
<th>The crane owner (contractor) is responsible for:</th>
</tr>
</thead>
<tbody>
<tr>
<td>- provide a crane that is properly maintained, tested and certified</td>
<td>- supplying the appropriate certified equipment and competent persons</td>
</tr>
<tr>
<td>- provide a competent driver</td>
<td>- planning the lift and operation of the safe system of work</td>
</tr>
<tr>
<td></td>
<td>- organisation and control of the lifting operation</td>
</tr>
</tbody>
</table>

6. Complexity of lift
The duties and extent of planning involved for a lift will vary depending on its complexity. Lifts are categorised into basic, standard or complex. The categorisation is a function of the level of hazards present within the area of the crane operation, which are established through the risk assessment process. Detailed guidance is provided in BS 7121-1.

7. 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 Appointed Person 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 Appointed Person 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.

8. Crane selection and access
The choice of a suitable mobile crane is governed by a number of factors including the characteristics of the load to be lifted (weight and dimensions), radii, heights of lifts, areas of movement, frequency and types of lifting operations, length of time on site, ground conditions and space available for access, erection, travelling, operation and dismantling.
9. Siting
The siting of the crane should take into account the crane standing and support conditions, the effect of wind and the adequacy of access to allow the placing or erection of the crane in its working position, as well as dismantling and removal from site. Particular care needs to be taken when siting mobile cranes in or near the ‘danger area’ at the edge of open trenches and excavations as these are likely to collapse without warning (see C703). An engineering assessment by a competent geotechnical engineer is required before setting up in such a location.

10. Checklists
The management, planning and execution of a crane lift has 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.

Ground conditions
The mechanism of overturning is often as a result of a failure of the ground or supporting structure beneath the crane or its outriggers. The following aspects are key to ensuring an adequate foundation is provided.

11. Site categories and underground hazards
Sites can be split into a number of categories to highlight the most likely hazards that need to be considered and risk assessed. More attention is required to establish the strength of the ground where ground conditions are poor or where there is a lack of data on the nature of the subsoil. Typical categories include:

- **Greenfield sites** - particular problem areas are adjacent to rivers, estuaries and floodplains where soft alluvial deposits and high groundwater tables can be expected.
- **Beaches** - low sand density and a variable groundwater level can create difficult conditions.
- **Brownfield sites** - unknown previous use including basements, storage tanks, poorly-filled open pits and poorly-compacted fill, etc.
- **Paved areas** - tarmacked or paved areas can appear deceptively strong but lead to outriggers punching through weak surfacing. Lightly-trafficked car parks, estate roads and footpaths should be scrutinised. The edge of paved areas are usually weak.
- **Town centre sites** - expect underground hazards including services, drainage pipes, buried cables, basements and tunnels, etc. beneath paved areas. This can lead to outriggers punching through to the void below.

13. Ground investigation
Before a crane arrives on site, existing information on the nature of the soils should have been studied. Reference should be made to any existing site investigation reports, and particular attention paid to the character of the ground at shallow depths where mobile cranes will be sited.

14. Ground bearing capacity
An assessment of the ground bearing capacity is required to determine the size and type of crane foundation required. This can be calculated with reference to the ground investigation reports and should be carried out by a competent geotechnical engineer. It should be noted that the presence of water tends to reduce the strength of soils and can lead to a reduced capacity since the initial bearing capacity assessment.

15. Settlement
Settlement must be kept to a minimum to avoid the slewing ring being out of the horizontal; resulting in the jib not being in a vertical plane. This can result in side loads on the jib and possible failure of the jib. Excessive settlement can also attract additional load onto the outriggers or track that is settling. Level indicators and inclinometers should be employed. If settlement occurs then the foundation needs to be reassessed.

16. Working platforms and design
A working platform may be required to provide a designated area of the site over which mobile and crawler cranes can travel during their delivery and movement around the site, lifting operations and removal. The design, installation, maintenance and repair of the working platform should be the responsibility of the main contractor. The appointed person should consult with a temporary works engineer on the detailed requirements. The platform should be free-draining to prevent the build-up of water. In certain cases, separation/filter membranes may be required beneath the platform. Appropriate factors of safety should be employed in the design and regular checks undertaken to ensure the platform is not disturbed by other construction activity. Excavations, trenches, or other holes dug must be properly backfilled and repaired to avoid creating soft spots. The edge of the platform needs to be clearly defined and
ground preparation should extend beyond the working area required.

17. Working Platform Certificate
Consideration should be given to using a 'Working Platform Certificate' to ensure that the correct procedures have been followed, the ground is adequate to support crane activity and that there are no irregularities that could result in local subsidence and toppling. Further detailed guidance on working platforms for tracked plant and a sample working platform certificate is available from the Federation of Piling Specialists. The issue of a 'Working Platform Certificate' should be an aspect of the 'Permit to Lift'.

18. Outrigger foundations
Outriggers to mobile cranes should always be fully extended and all the tyres lifted clear of the ground. The area of the pad attached to the outrigger of a mobile crane is small and therefore generates high pressures on the ground. The pressure can be reduced by the provision of suitable spreader mats which, depending on the allowable bearing pressure of the subsoil, could consist of timber mats, timber and ply plates, proprietary mats, steel grillages, concrete pads or piles (for high loads in week soil conditions). Calculations will be required and the Appointed Person should consult with the temporary works design engineer and crane supplier. Outriggers should always be positioned central to the spreader mats, which should be in contact with the ground over its entire surface area.

Legislation

21. 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 here.

References and guidance:

- BS 7121-3:2000 – Mobile cranes
- 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)
- Working Platform Certificate (www.fps.org.uk)

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 HSBEI guidelines, nor does it guarantee that related losses will not occur.

HSB-LCE-RGN-008 Rev: 0 Date: 23/05/2014
Case Study 1

Two construction companies were prosecuted by the HSE following the overturning of a 35-tonne truck-mounted telescopic crane on site. The collapse occurred after one of the outriggers, which supported the crane, sank into the ground.

The crane driver was forced to leap to safety and the 5.7-tonne beam that was being lifted into place narrowly missed two employees as it fell. The principal contractor and crane operator were both fined and ordered to pay substantial costs.

The incident could have been avoided had the planning and supervision of the lifting operation not been so deficient. The crane overturned because it was being operated, with the knowledge of both companies, in a part of the site that had not been prepared for such activities. The roadway was not wide enough to accommodate the outrigger spread of the crane. Clear warnings were ignored in the run-up to the incident about the ground bearing capacity for the use of cranes on the site. The risk assessments which had been produced were inadequate as they only considered use at a completely different part of the site.

Case Study 2

The principal contractor and crane hire company were ordered to pay a substantial fine and costs after a serious communications failure led to a mobile crane toppling over on site. The extended 50-metre jib fell across the site, narrowly missing workers and a nearby busy road.

The 80-tonne crane was supplied and operated by the crane hire company but confusion arose as to whether the job had been set up on a ‘crane-hire’ only or ‘contract-lift’ basis (where planning of the lifting operation is included).

This meant both firms neglected the planning of the lift and led to vital roles for the job not being assigned.

A competent person should have been appointed to plan the lift, either provided by the crane hire company if it was a contract hire arrangement or by the hirer if it was a hire-only agreement. The crane hire company should have ensured this happened when it set up the contract.

Important information — including the weights being lifted and ground conditions — were not passed on to the workers involved. The crane was overloaded and was being operated on poor ground. A larger crane and ground mats to spread the load of the crane’s outriggers should have been used.
Site overturning hazards and control measures

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

<table>
<thead>
<tr>
<th>Overturning hazard</th>
<th>Controls to mitigate the risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure of the ground</td>
<td>Undertake a suitable and sufficient site investigation to determine the nature of the ground conditions. Ensure a suitably designed and compacted working platform is installed and maintained.</td>
</tr>
<tr>
<td>Unstable/uncompacted working surface</td>
<td>Obtain existing services drawings and undertake trial pits, probing and cable detection to identify all buried services and voids.</td>
</tr>
<tr>
<td>Underground hazards including services, drainage pipes, buried cables, basements and tunnels, etc. beneath paved areas</td>
<td></td>
</tr>
<tr>
<td>Open excavations and slopes</td>
<td>Ensure crane is set up a suitable distance from the edge of open excavations and slopes.</td>
</tr>
<tr>
<td>Poor ground conditions – adjacent to rivers, estuaries, marshes, floodplains, beaches, landfill sites and areas with a high groundwater level</td>
<td>Undertake a suitable and sufficient site investigation to determine the nature of the ground conditions. Monitor groundwater and soil saturation levels. Ensure a suitably designed and compacted working platform is installed and maintained. Use suitable bearing plates beneath outriggers.</td>
</tr>
<tr>
<td>Management and planning failures</td>
<td></td>
</tr>
<tr>
<td>Inexperienced supervisors and crane operators</td>
<td>Ensure only competent, trained persons are employed (see BS 7121-1). Consider a Contract Lift if competence of supervisors is in doubt.</td>
</tr>
<tr>
<td>Unclear roles and responsibilities</td>
<td>Ensure key positions are established and individuals appointed by letter detailing their roles and responsibilities.</td>
</tr>
<tr>
<td>Movement or set-up in unauthorised locations</td>
<td>Provide a sketch illustrating the permissible set-up location(s) and allowable access route(s). Prevent access to unsafe areas.</td>
</tr>
<tr>
<td>Uncontrolled lifting operations</td>
<td>Ensure all lifting operations are subject to a Lifting Plan, including a risk assessment, a method statement and a ‘Permit to Lift’.</td>
</tr>
<tr>
<td>Incorrect factor of safety in design of working platform</td>
<td>Ensure a competent designer is employed and suitable Factor of Safety (FoS) used. Clarify if the design criterion refers to ultimate bearing capacity (ground failure) or allowable bearing pressure (including an FoS). See C703 for guidance.</td>
</tr>
<tr>
<td>Overloading</td>
<td></td>
</tr>
<tr>
<td>Load too heavy</td>
<td>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.</td>
</tr>
<tr>
<td>High wind loading</td>
<td>Establish site wind speed limits (red/amber/green). Use an anemometer to monitor in-service wind speeds. Monitor weather forecasts.</td>
</tr>
<tr>
<td>Lifting radius too high</td>
<td>Stay within the agreed lifting location and radius. Avoid swinging loads or travelling with high loads.</td>
</tr>
<tr>
<td>Mechanical failure</td>
<td></td>
</tr>
<tr>
<td>Poorly maintained crane</td>
<td>Ensure crane is regularly maintained in accordance with the LOLER and PUWER Regulations and thorough examinations performed.</td>
</tr>
</tbody>
</table>