



International Crane Stakeholder Assembly

- Guidance -

“Using Mobile Cranes with freely suspended vibratory equipment for Pile Driving / Extraction”

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Legal Note: *This publication is only for guidance and gives an overview regarding the assessment of risks related to using mobile cranes for pile driving/extraction. This document is an industry best practice document that is based on the consensus of member organizations of ICSA. It is not a regulation or standard and should not be treated as such. It neither claims to cover all aspects of the matter, nor does it reflect all legal aspects in detail. It is not meant to, and cannot, replace own knowledge of the pertaining directives, laws and regulations. Furthermore the specific characteristics of the individual products and the various possible applications have to be taken into account. This is why, apart from the assessments and procedures addressed in this guide, many other scenarios may apply.*



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1. INTRODUCTION

Mobile cranes (both wheeled and tracked), utilizing either a lattice or telescopic boom are designed to lift and move freely suspended loads. International Mobile Crane Manufacturers and Users organized as ICSA (International Crane Stakeholder Assembly) are aware of the use of mobile cranes in conjunction with freely suspended vibratory equipment for pile driving/extraction applications. This type of use presents unique hazards that can increase risk, requiring additional considerations to be reviewed prior to commencing operations.

Proper planning can help avoid negative influences that may affect the crane and lifting attachments during pile driving/extraction applications. Inadequate crane capacity, boom length, and the high potential for vibrations and shocks to be transmitted to the crane can create unique hazards, all of which could result in a dangerous situation.

It is essential to identify and observe all applicable national or local regulations and standards that may exist and shall be observed.

2. SCOPE

This document applies when mobile cranes designed for lifting loads are used in freely suspended vibratory pile driving/extraction applications and is complementary information to the manufacturer's operation manual and any corresponding safety warnings. It applies to all types of mobile cranes as defined in standards such as EN13000, AS 1418.5, ASME B30.5 or CSA-Z 150 and is meant to provide guidance in the assessment of risks.

This guideline refers only to freely suspended vibratory pile driving/extraction equipment without the use of lead systems, impact hammering is not included.

3. DEFINITIONS

Lifting attachment – equipment which is used to attach the load to the lifting appliance, for example a sling or a shackle.

Mobile Crane - jib crane, which may be fitted with a mast (lower attachment) capable of travelling, laden or unladen, without the need for fixed runways and which relies on gravity for stability (ISO 4306-2)

Pile - A column or foundation element (e. g. sheet pile and casings) which is driven into the ground and is used to resist axial and/or lateral loads.

Pile run - A pile run is the unexpected (faster) movement of a driven pile, when the pile e. g. hits a void.

Slack (rope) - A rope is slack, when it is not under tension, and the rope between two points is longer than the direct distance between these points.

Vibratory hammer - it is a pile driving and extracting unit which is mechanically connected to a pile and drives or extracts the pile by oscillating it through the soil. Power source may be either electric or hydraulic.

Vibratory pile driving - pushing a pile by means of oscillating forces

Vibratory pile extraction - pulling a pile by means of oscillating forces

4. GENERAL

As previously noted, mobile cranes are not specifically designed for pile driving/extraction applications. If dedicated equipment designed for pile driving/extraction is available to carry out the task, it should be used. However mobile cranes may be used for pile driving with freely suspended vibratory pile driving equipment if it is the more feasible way to carry out the task and is approved by an authorized person or the mobile crane manufacturer in accordance with the local regulations. Pile driving equipment should only be suspended from the crane's main boom and not from luffing or fixed jib configurations.

Precautions are necessary when mobile cranes are used to perform pile driving/extraction. The aspects mentioned in the following paragraphs are based on crane industry knowledge and experience. They should be reviewed before planning and starting any operation involving driving or extraction of piles and should not be used as a substitute for a jobsite risk analysis.

Some cranes may be equipped with specific operation modes for pile driving/extraction. If there is no such specific operation mode and if there are no further requirements provided by the crane manufacturer, the maximum load acting on the crane and its components (e. g. hook block) should be maintained below 50% of the rated capacity (load chart) of the chosen configuration while driving or extracting the pile. This is not required during the picking and positioning of the pile prior to driving or after being pulled free of the ground as it is considered a load to be lifted within the crane's full rated capacity.

When planning for the use of mobile cranes for pile driving/extraction, a risk assessment should be completed for the task. Elements of the risk assessment to be considered are covered in Annex B.

Prior to commencing operations, the piling contractor should know the length of the longest pile to be driven and the working height of the vibratory hammer. The piling contractor should ensure that the mobile crane configuration chosen provides enough lifting height (head height) to maintain sufficient clearance between the vibratory hammer and the boom.

5. VIBRATORY PILE DRIVING/EXTRACTION

5.1. General

Avoid transferring excessive vibrations and shock loads to the mobile crane.

5.2. Vibratory hammers

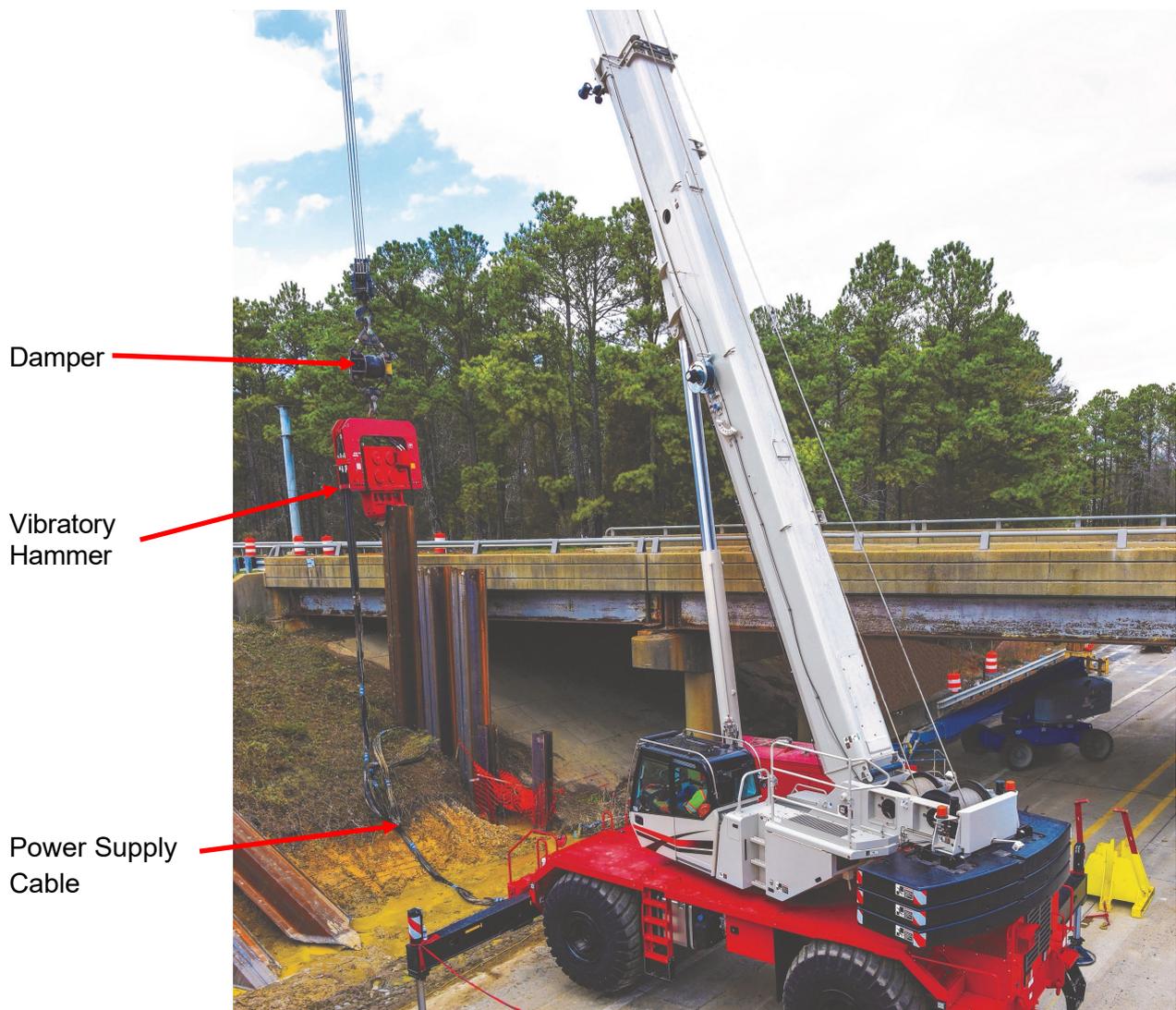


Figure 1: Typical Crane Suspended Vibratory Hammer

The vibratory hammer is typically freely suspended from the crane as shown above. Some tension should always be applied to keep the hammer upright and sitting square on the pile top at all times. The operator should pay close attention to not allow the vibratory hammer to lean over and possibly damage or break the pile top.

Modern vibratory pile hammers do have internal isolators that may help minimize the forces on the lifting crane, but they are primarily installed to protect the hammer itself. A suitable isolation

between the hook and the vibratory hammer should always be used for pile driving/extraction work (e. g. damper).

5.3. Ground assessment and considerations

5.3.1. Pile driving

Pile driving is a complex process that requires accurate calculations and testing because it alters how the soil around the pile will behave and soil, particularly in a large area, can vary greatly. Therefore, preparation and contingency planning are key to any pile driving project. Pile foundation design is highly dependent on the soil the piles are driven into. Other factors include the material of the piles, the expected load, and anticipated level of use. Prior to beginning any pile driving operation, a planning process is required and should include extensive and careful soil testing. Testing and evaluation should continue during installation of the piles.

Problems during pile driving are typically related to adverse or unexpected changes in soil conditions, which can lead to pile damage, hammer-pile alignment problems, and other issues. In most cases, stopping the work and testing the soil, reviewing calculations, and inspecting the equipment will help to determine the cause of the problem. Key decisions should be based on a geotechnical risk assessment. Planning prior to commencing work should include measures for risk mitigation. Possible soil issues can include greater soil strength than anticipated, temporarily increased soil resistance with later relaxation, large soil quakes, or high soil damping.

The term pile running refers to the quick penetration of a pile into the soil. Unexpected pile running can cause shock loading to the lifting attachments, crane hoist rope, and the crane boom.

5.3.2. Mobile crane set-up

Adequate preparation of the ground supporting the mobile crane during operation and on-site travel is essential for maintaining crane stability.

Crane manufacturers develop rated capacity charts based on cranes standing or installed on a level, firm and uniform supporting surface. Unless otherwise specified by the crane manufacturer, level means the surface of the supporting area for the crane has less than 1% gradient (0.57°). For cranes on outriggers, levelling the crane to the manufacturer's specifications can be achieved with outrigger adjustment to fine tune variations in the supporting surface. For crawler cranes, additional matting and shimming may be required to create the required level supporting surface to get the crane level within the manufacturer's specifications. The crane supplier and controlling entity should determine who will supply the matting and shimming to level the crane.

The expected soil bearing pressures during operation and travel may require additional measures to either distribute the load over a larger surface or improve the soil bearing capacity. Expected soil bearing pressures for lifting or laying down the pile, during pile driving and extraction and travel movements may vary significantly. The crane supplier and controlling entity should determine during the planning stage who will implement any additional measures.

5.3.3. Mobile crane preparation

The following preparation of the mobile crane should be done before commencing piling work:

- remove all hook block cheek weights unless they are permanently attached.
- remove stowed jib / unused attachments.
- remove unused pendants, rollers, etc.
- secure split pins, r-clips, nuts to resist loosening due to vibration.

5.4. Loading during pile driving and extraction operation

To reduce dynamic loading to the crane, a qualified person, considering jobsite conditions, should determine how much (if any) tension should be allowed during pile driving in the connection between hook and pile driving/extraction equipment taking into consideration the case of a sudden pile run.

There is always tension on the crane hoist line attached to the vibratory hammer used to extract piling. Although the weight of the pile driving unit and the pile itself is known and the actual load is displayed to the crane operator, friction forces during extraction can vary. Therefore, as mentioned previously it is important to monitor the load during extraction of piles and ensure it remains below 50% of the rated capacity (load chart) for the chosen configuration.

Note: Often the actual load indication may not react fast enough to show the true load on the crane as tension is being applied to a fixed load, so caution must be exercised to apply the load slow enough for the actual load indication to react. Also, the peak loads applied to the crane when using vibratory equipment may not be registered.

It is essential to understand that there may be vibrations transmitted to the crane causing additional cyclic forces to the mobile crane, even if a damping device is used between the pile extracting unit and the crane hook. Based on the frequency of the vibration, which is typically between 25Hz and 40Hz (depending on the vibro-system), and the corresponding fast load fluctuation, the load displayed to the crane operator may only be an average load value. Tension on the hoist rope when driving or extracting piles can transmit cyclic vibration loads into the crane structure and mechanisms and may lead to premature fatigue which can result in cracks or failure of parts.

5.5. Inspection of the crane and equipment prior, during and after pile driving/extraction work

Prior to pile driving / extraction, inspect the pile, the vibratory hammer, clamp, jaws, power unit, damper, and supply hoses in accordance with their manufacturer's recommendations. Associated equipment, such as the couplings, support and lifting equipment, rigging, retaining bolts, and or other items required by the manufacturer, should be inspected before each shift and regularly during use. Repair or replace faulty items prior to use.

Based on a risk assessment, a thorough visual inspection as well as functional tests should be made frequently while the crane is being used for pile driving or extraction work (see Annex A).

Carry out a thorough inspection equivalent to an annual inspection, before the crane is returned to regular lifting services.

All inspections should be done by a competent person and any deficiencies corrected prior to return to service.

5.6. Additional equipment considerations

Although an additional damper may be used, remaining vibrations can be transferred to the crane during pile driving and extraction. Vibrations have been shown to be particularly damaging to mobile cranes and in addition to damaging the crane, they may cause hazards to persons in the vicinity of the crane.

Therefore, additional items that should be considered include, but are not limited to, the following:

- the possibility of components falling off the boom (e. g. lock pins, brackets)
- loosening or detachment of hydraulic components due to fatigue
- breakage of the rope securing pins on the boom or the hook block
- damage to the hook block and overhaul ball especially on the shaft in the area of the thread and cheek weights coming loose
- rope tangling on the winches
- damage to sensors (e. g. A2B, RCL system components)
- damage to the boom extension system

6. GUIDANCE REGARDING DRIVING/EXTRACTION OF PILES

Pile driving/extracting with a Mobile Crane is under the full responsibility of the crane owner/user. Any vibrations transferred to the crane may create damages and can reduce the service lifetime of the crane.

At a minimum, the following should be considered when mobile cranes are to be used for pile driving/extraction with freely suspended equipment:

a) General

- Completion of a risk assessment for the pile driving or extraction task, with the involvement of a competent person familiar with the hazards associated with pile driving/extraction.
- A rated capacity limiter (RCL) installed, functioning properly, programmed according to the actual crane configuration, and not deactivated or bypassed at any time.
- Use of damping units between the hook and the vibratory equipment to minimise vibrations transferred back to the crane structure.
- If no specific operation mode for pile driving and extraction is provided by the crane manufacturer, the loading of the crane while driving or extracting the pile should remain below 50% of the rated capacity.
- Side-loads on the boom should be avoided during all pile-driving and extraction operations.
- When removing the driving unit from the pile, position the hook block vertically above the attachment point.
- Vibrations transferred to the crane during pile driving/extracting work may damage parts of the crane by premature wear and fatigue; as a consequence, inspection frequency and content should be adapted accordingly (e.g. checks for cracks and loose parts).



- Before the crane is used again for normal lifting operations, ensure a thorough inspection of the crane is done.
 - Follow the instructions and restrictions provided by the pile driving equipment manufacturer(s)
- b) Pile driving
- Before starting the driving operation, avoid tipping of the pile on the ground to prevent any side load acting on the crane.
 - Do not start the driving unit until the full weight of the pile and pile driving equipment are resting on the ground with a minimal amount of tension in the connection between hook and vibratory hammer. This might require external support to assist holding the pile.
- c) Pile extraction
- high boom angles should be avoided to prevent boom “kickback” if sudden pile run or issues with the lifting attachment occur.
 - apply tension to the hoist line slowly and carefully to avoid overloading the crane.
 - before the pile is pulled free from the ground, stop the vibratory hammer, to avoid excessive vibrations being transferred to the crane.
- d) Pile driving and pile extraction in cold weather
- The crane manufacturer's general instructions for cold weather operations should be followed.
 - The pile driving/extracting equipment manufacturer's general instructions for cold weather operations should be followed.
 - Hydraulic systems of cranes and vibratory hammers should be equipped with low-temperature hydraulic fluids and / or hydraulic tank heaters to ensure the hydraulic system functions properly.
 - In addition to pre-shift checks according to clause 5.5, ensure that structural components are checked for any cracking or damage.



Annex A
(Informative)

Example Crane Inspection List

CLIENT: _____

DATE: _____

CRANE TYPE: _____

SITE LOCATION: _____

CRANE CAPACITY: _____

SERIAL NO.: _____

INSPECTION	INSPECTED	COMMENTS
<u>BEFORE COMMISSIONING</u>		
CONSULT WITH CRANE MANUFACTURER OR ENGINEER FOR USE OF CRANE IN PILING OPERATIONS		
ALL HOOK BLOCK CHEEK WEIGHTS REMOVED		
STOWED JIB/ UNUSED ATTACHMENTS REMOVED		
UNUSED PENDANTS, ROLLERS ETC REMOVED		
SPLIT PINS, R-CLIPS, NUTS SECURED TO RESIST LOOSENING DUE TO VIBRATION		
<u>PRE-SHIFT OPERATIONAL CHECKS</u>		
ALL WELDS ON HOOK BLOCKS TO BE VISUALLY INSPECTED		
ALL BOLTS AND SAFETY PINS ON HOOKS TO BE INSPECTED FOR CORRECT SETTINGS		
ALL SHEAVES TO BE VISUAL CHECKED FOR CRACKS		
ALL SHEAVE BEARINGS TO BE CHECKED FOR FREE MOVEMENT AND LUBRICATION		
INSPECT ALIGNMENT MARKS ON THE TRUNNION BEARING NUT, TO ENSURE NO MOVEMENT HAS TAKEN PLACE.		
<u>WEEKLY INSPECTIONS</u>		
CHECK RCL ACCURACY		
LAY BOOM DOWN AND INSPECT THE FOLLOWING ITEMS.		
1) ANTI TWO BLOCK SWITCHES AND MOUNTING BRACKETS.		
2) ANEMOMETER AND MOUNTING BRACKET		
3) BOOM CONNECTION PINS AND LOCKING PINS		
4) PENDANT BAR PINS AND LOCKING PINS		
5) CONDITION AND LUBRICATION OF HEAD SHEAVES AND BEARINGS.		
6) ROLLER GUIDES ON TOP OF BOOM SECTIONS		
7) VISUAL INSPECTION OF COMPLETE BOOM FOR DAMAGE AND / OR CRACKED WELDS		
8) ALL HOIST AND LUFFING ROPES TO BE VISUALLY INSPECTED		
9) VISUALLY INSPECT ALL BRACKETS ON BOOM HEAD FOR SECURITY OR CRACKING ON WELDS		
<u>ADDITIONAL COMMENTS</u>		
SIGNATURE OF PERSON CARRYING OUT INSPECTION:		
DATE:		

Annex B (Informative)

Elements of Risk Assessments

In addition to risks associated with general lifting operations, elements of the risk assessment related to pile driving or extraction activities are covered in this annex.

Elements to be considered are:

- calculation of extraction forces
- the required staging area for the piles to be lifted to their suspended position and proximity to other equipment, personnel, and overhead services or underground utilities
- pile stability at near vertical position as shown in Figure 2

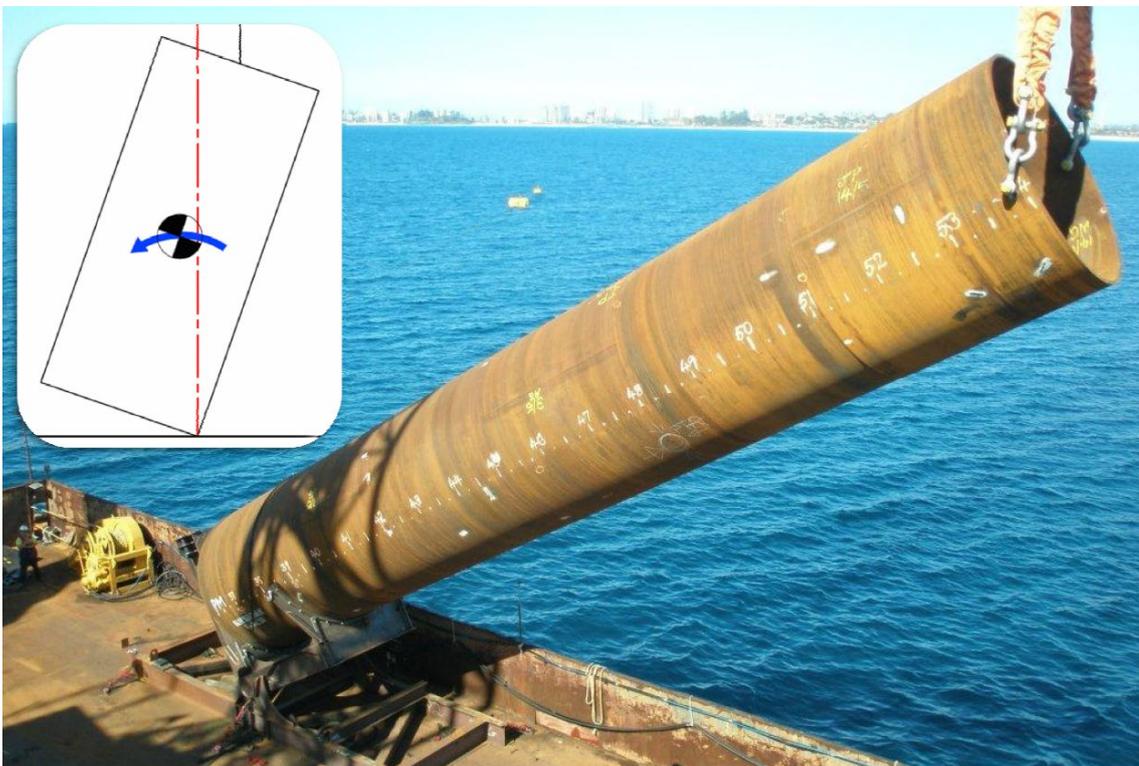


Figure 2: Centre of Gravity is past point of rotation at near vertical position.

- suitability of lifting attachment for working environment.
For example, round slings should not be wrapped directly on objects with sharp edges.
- exclusion zone during piling operations
- geotechnical report for soil composition
- means of adjusting the pile orientation during driving operations
- retention of the base of the pile when driving commences, e. g. cage
- secondary method of retention for reused temporary works piles where fatigue fracture can occur
- controlled test of extraction method selected

You will find more information in a guideline from PDCA (Pile Driving Contractors Association) with the title:

- *Pile Driving Safety and Environmental Best Management Practice (September 19, 2017)*



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AS 2550.5	<i>Cranes, hoists and winches – Safe use, Part 5: Mobile cranes</i>
ASME B 30.5	<i>Mobile and Locomotive Cranes</i>
ASSP ¹ A10.19	<i>Safety Requirements for Pile Installation and Extraction Operations</i>
EN13000	<i>Cranes – Mobile Cranes</i>
ISO 4301-2	<i>Cranes – Classification – Part 2 Mobile Cranes</i>
CSA-Z 150	<i>Safety Code on Mobile Cranes</i>
PDCA ²	<i>Pile Driving Safety and Environmental Best Management Practice</i>

¹ ASSP – American Society of Safety Professionals

² PDCA – Pile Driving Contractors Association



ICSA MEMBERS

This document has been reviewed and jointly adopted by the following member associations of the ICSA:

- **Association of Equipment Manufacturers [AEM]**
- **The Crane Industry Council of Australia [CICA]**
- **The Crane Rental Association of Canada [CRAC]**
- **The European Association of abnormal road transport and mobile cranes [ESTA]**
- **European Materials Handling Federation [FEM]**
- **Japanese Crane Association [JCA]**
- **Specialized Carriers & Rigging Association [SC&RA]**

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