Mechanics Of A Super Lift

ALE 5000-Ton Crane – World Record Lift of Six Derricks – Lifted Weight 1.627 tons @ 174 feet radius
Introduction

JOSEPH S. COLLINS

Joseph (Joe) Collins is the Heavy Lift Manager for Becht Engineering Co., Inc. He is providing Consulting and Design Services for Lifting and Transport of process equipment, machinery, chemical, refining and nuclear vessels and components.

His duties include consulting to clients using the world’s largest cranes and super heavy lift projects. In addition, he is assisting major companies in updating their crane and rigging policies to assure compliance with the new OSHA crane rule.
Introduction

Collins has over 40 years experience in Heavy Industrial Construction, specializing in Critical Lift Planning and Execution, based on his long-term career with Zachry Construction Corporation (ZCC).

He currently serves as Vice President of the Board of Directors for the National Commission for the Certification of Crane Operators (NCCCO).

Mr. Collins served as a member of the Cranes and Derrick Advisory Committee (C-DAC) to OSHA, which wrote and delivered the current draft of the new OSHA Crane Safety Standard.
Definition of a Super Lift

There is no definition for a Super Lift in any current Standard.

However, many companies that make extreme lifts within their facilities have coined the term and created their own definitions.

The intent is to minimize risk by requiring a comprehensive engineered lift plan followed by a third party review of the plan.
Definition of a Super Lift

The definitions vary between companies but all are intended to achieve the same result.

This system of checks and balances has proven value and has resulted in the safe lifting of massive objects worldwide.

An accident with these heavy loads and giant cranes would be catastrophic both to human life and the facilities.
Definition of a Super Lift

Some criteria in the definitions are:

• Lifting with a crane rated at 1000-Ton Capacity or higher

• Lifting with a crane equipped with capacity enhancing attachments

• Any lift that presents a risk of catastrophic damage to human life or the facility
Presentation Outline

• Ground Bearing Pressure
• Crane Suitability
• Rigging Assemblies
• Lift Procedures
• Personnel Qualifications
• Heavy Lift Manuel
Ground Bearing Pressure and Load Distribution Analysis

- Soil Analysis
- Load Distribution Systems (foundations)
- Underground Structures and Cavities
Soil Analysis

– The allowable ground bearing capacity has to be investigated and confirmed by an experienced soils engineering firm.
# Sample Soil Report

<table>
<thead>
<tr>
<th>LOCATION</th>
<th>See Exhibit A-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEPTH</td>
<td>WATER CONTENT (%)</td>
</tr>
<tr>
<td>5.0</td>
<td>SANDY LEAN CLAY (CL), very dark gray, stiff</td>
</tr>
<tr>
<td></td>
<td>-very stiff at 3.5’</td>
</tr>
<tr>
<td>8.5</td>
<td>CLAYEY SAND (SC), dark yellowish-brown and light olive-brown, stiff</td>
</tr>
<tr>
<td></td>
<td>SANDY LEAN CLAY (CL), olive-brown, stiff</td>
</tr>
<tr>
<td>13.5</td>
<td>FINE SAND (SP), brownish-yellow, loose</td>
</tr>
<tr>
<td>19.5</td>
<td>FINE TO MEDIUM GRADED SAND (SP), yellowish-brown, loose</td>
</tr>
<tr>
<td>25.0</td>
<td>-medium dense below 23.5’</td>
</tr>
</tbody>
</table>

Boring Terminated at 25 Feet
The site surface cover generally consisted of gravel. The soil profile generally consisted of lean clay with varying amounts of sand to depths of about 13.5 feet underlain by fine to medium sand to below the boring termination depths. Groundwater was encountered at depths of 13.5 feet in the test boring at the time of field exploration.

Based on the subsurface conditions encountered and expected loads, shallow foundations could be used to support the proposed structures. Foundation design recommendations for the proposed structures are presented in the following table.

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation Type</td>
<td>Shallow foundation</td>
</tr>
<tr>
<td>Bearing Material</td>
<td>6 inches of ODOT Type “A” crushed aggregate base(^2) over undisturbed native soil</td>
</tr>
<tr>
<td>Net Allowable Bearing Pressure(^1)</td>
<td>2,500 psf</td>
</tr>
<tr>
<td>Total Estimated Settlement</td>
<td>1 inch</td>
</tr>
<tr>
<td>Estimated Differential Settlement</td>
<td>Approximately 1/2 of total settlement</td>
</tr>
</tbody>
</table>

\(^1\) The recommended net allowable bearing pressure is the pressure at the base of the shallow foundation in excess of the adjacent overburden pressure. Assumes any unsuitable materials, if encountered, will be undercut and replaced with engineered fill.
Ground Bearing Pressure and Load Distribution Analysis

• Foundations
  – Depending on the type of lift equipment, cranes or gantry systems, the foundation is designed based on the allowable ground pressure.

  – The foundations may consist of:
    • piling with a concrete cap
    • wood and or steel crane mats
    • compacted fill
    • all of the above
Sample Ground Bearing Pressures

- Terex CC6800 – 1200-Ton Capacity
  - GBP = 12,700 psf

- Liebherr LTM 11200 – 1200-Ton Capacity
  - single outrigger force 418,000 lbs.

- Mammoet PTC Ringer – 3500-Ton Capacity
  - GBP = 3,400 psf
2000-ton Gantry System (Mammoet)
Sample Foundation Design with Piles and Concrete Cap
Sample Foundation Design with Piles and Concrete Cap
Piling Installation
3500-Ton Ring Crane (Mammoet)
Sample Foundation Design

3500 psf
Foundation Design 3-D Model
Sample Ground Pressure Calculation

\[ q = \frac{9.701 \times 3.917}{71 - 71} = 5.011 \text{kips/ft} \]

Steel spreader, \( W = 7.71 \text{kips} \)

Steel mat

\[ q_{\text{act}} = 2.3 \text{ ksf} \]
\[ F.S. = \frac{2.4}{2.3} = 1.05 < 1.5 \]

\[ q_{\text{avg}} = 2.113 \text{ ksf} \]
\[ F.S. = \frac{2.4}{2.13} = 1.13 < 1.5 \]

\[ q_{\text{ult}} = 1.6 \text{ ksf} \]
\[ F.S. = \frac{1.5}{1.5} = 1.0 \]

\[ q_{\text{ult}} = 2.14 \text{ ksf} \] (Provided)
Underground Structures

A thorough investigation must be done to identify underground structures or buried cavities under or near the crane foundation.

Some good sources are:

- Site Owner records and drawings
- Sounding with sonar equipment
- These hazards are sometimes exposed during excavation while improving the ground for the crane foundation
Becht Engineering highly recommends proof testing the foundation

• Static Test – Load the foundation with enough weight to simulate the ground bearing pressure the crane will apply.
  – This can be done with the crane counterweights
  – Measure the foundation elevation before, during and after the load is applied
Proof Test the Foundation

• Static Test the Foundation
  – Select a test weight that, at a given boom angle, will simulate the ground bearing pressure applied by the crane
  – The test weight only needs to be raised until it is freely suspended
  – Measure the foundation elevation before, during and after the test lift is conducted

Any settlement more than the engineered allowable is unacceptable and the foundation must be modified
Foundation Failure
Crane Suitability

- Crane capacity and proper configuration
- Assembly and Disassembly Procedures
- Inspection Records
- Maintenance Records
ALE 5000-Ton Crane
The new cranes with super lift counterweights are often misunderstood by the lay person.

They have to achieve somewhere between 80 and 90 percent of capacity to float the auxiliary counterweight.

For some time now, the facility owners wanted to limit lifts to 75 percent of capacity. This is a good idea for conventional cranes but does not necessarily work for super lift cranes.
Selection of the right crane and attachments is critical.

- The super cranes have a large foot print and adequate room is required
- Erecting the boom is a major consideration as they can be 400 plus feet long
Crane Capacity and Proper Configuration

TC 36000 – 2500-Ton VersaCrane
Deep South Crane and Rigging
Review the inspection records of the crane

• Look for recurring problems that have been addressed multiple times

• Use this information to zoom in on problem areas while the crane is being erected and during the final inspection
Maintenance Records

Review the maintenance records of the crane

• Look for recurring problems that have been addressed multiple times

• Use this information to assure a specific spare parts are on hand

• Assure commonly used spare parts are on hand
Rigging Assemblies

- Check Rigging Configurations for Capacity
- Analyze Rigging Configuration for Stability
- Analyze Below the Hook Lifting Devices
- Analyze Points of Attachment
- Assure Compliance with Current Regulations
2000-Ton Capacity Rigging System (Versabar)
Rigging System (Versabar)
Rigging Detail (Holloway Houston)
Proof Testing 1500-Ton Lifting Lug (Holloway Houston)
Proof Testing 1500-Ton Lifting Lug (Holloway Houston)
Compliance with Current Standards

- OSHA 1926.1400 Subpart CC
  - Cranes and Derricks in Construction
- ASME BTH-1
  - Design of Below-the-Hook Lifting Devices
- ASME B30.5
  - Mobile and Locomotive Cranes
- ASME B30.9
  - Slings
- ASME B30.10
  - Hooks
- ASME B30.20
  - Below-the-Hook Lifting Devices
- ASME B30.26
  - Rigging Hardware
Lift Procedures

• Check All Clearances

• Confirm all Radii are Within Crane Capacity

• Confirm Safe Wind Speed Limits

• Confirm that Rigging Personnel can Safely Attach the Rigging, Land the Load and Disconnect the Rigging
Check All Clearances

During the planning phase, check clearances for:

- Load to Boom
- Load to Obstructions
- Boom to Obstructions
- Remaining Head Room
- Counterweight to Obstructions
Check All Clearances
Mammoet PTC 3500-Ton
Check All Clearances
Mammoet PTC 3500-Ton
Check All Clearances
Mammoet PTC 3500-Ton
Check All Clearances
Check All Clearances
Check All Clearances
Confirm all Radii are Within Crane Capacity

Physically measure all radii in the field

• A tape measure is not much use due to obstructions

• Seek assistance from experienced field surveyors
Confirm Safe Wind Speed Limits

Wind Is Your Worst Enemy

• Refer to the crane manufacturers wind limit instructions

• Calculate the wind sail area of the load

• Determine what wind speed will move the load

Set the wind speed limit to the lower value

Keep in mind that even if the crane can safely lift the load, the riggers may not be able to safely control and/or land the load.
Confirm Personnel Safety

Confirm that Rigging Personnel can Safely Attach the Rigging, Land the Load and Disconnect the Rigging

- Is scaffolding needed and will it be erected for the riggers to work from?
- Will the scaffolding obstruct the load path?
- Will a crane suspended personnel platform be required to disconnect the rigging?

These considerations have to be included in the plan
Sample Scaffolding
Confirm Personnel Qualifications

- Review and Confirm the Crane Operator Qualifications/Certifications
- Review and Confirm the Lift Director Qualifications
- Review and Confirm the Rigging Crew Qualifications
Heavy Lift Manual

- Prepare a Comprehensive Lift Manuel containing all relevant support documents pertaining to the lift plan

- The manual will be a living document and will be modified as minor revisions are made to the overall plan.
The Heavy Lift Manual is intended to serve as a resource for all parties with responsibilities regarding the lift.

It eliminates errors by having everyone working from the same play book.

It serves as a legal document defendable in a Court of Law.
Heavy Lift Manual
Sample Table of Contents

• Administration Documents
  – Contractor Organizational Charts and Responsibilities

• Civil Engineering
  – Geotechnical Report
  – Site Survey
  – Underground Structures
  – Crane Foundation Drawings with Engineering Calculations

• Rigging Engineering
  – Rigging Diagrams, Load Calculations, Lift Plans
  – Rigging Certifications
  – Wind Speed Limits
  – Points Of Attachment Design Calculations and NDT Reports
  – Test Lift Plan
  – Personnel Lift Plan
Crane Assembly/Disassembly Procedures

- Crane Manufacturers Detailed Assembly Instructions
- Detailed Erection Procedure Including Elevation and Plan View Drawings
- A/D Checklist
- A/D Critical/Engineered Lifts
- Assembly Crane Configuration, Capacity Charts and GBP Calculations
- Assembly Crane GBP Mitigation Plans
- Rigging Certifications
- Plan for Personnel to Access Elevated Work
Heavy Lift Manual
Sample Table of Contents

• Crane Inspection Records
  – Annual Inspections Records
  – Frequent Inspection Records (pre-shift and or daily)
  – A/D Inspection Records
  – Wire Rope Inspection Records
  – Boom Pendent Strap Inspection Records
  – Maintenance Records
    • Repair Summery
    • Spare Parts List (strongly advised)
Heavy Lift Manual
Sample Table of Contents

• Safety Execution Plan
• Population Control Plan
• Risk Assessment, Controls & Mitigations
• Contingency Plans
• Emergency Procedures
• Incident Notification Plan
• Permits
• Lessons Learned
Third Party Review

Engineering Review
A formal engineering is highly recommended.

In the course of our reviews, we often discover and correct small mistakes in the engineering plans.

It is important to remember that most crane accidents are not the result of a single mistake but are the combination of several factors that come together at one time.
The third party engineering review not only eliminates mistakes but it also validates the lift plan in the event it has to be defended in court.
Third Party Field Monitoring

We also highly recommend that you have the third party monitor the crane erection and lifts.

This is to assure the plan is followed accordingly and the inevitable field changes to the plan are properly managed.

Often we find the rigging crew is so busy with their work that they can easily miss a step, permit or simply select the wrong sling or shackle from a pile of rigging.
Thank You