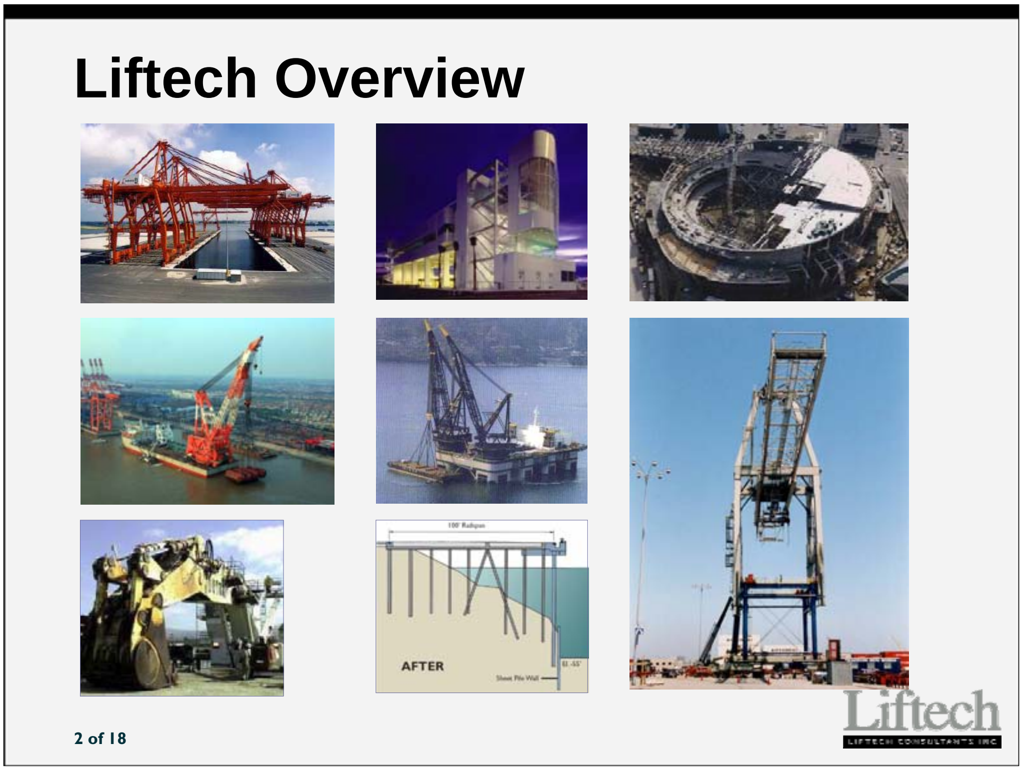
Colossal Cranes

STEER 2010

Erik Soderberg, SE
Vice President, Principal
Liftech Consultants Inc.
www.liftech.net



Liftech provides structural engineering services for a variety of structures, primarily container cranes.

We have designed and assisted in the design of some of the world's largest crane boom structural systems including the AmClyde twin 6000 and 7000 metric ton capacity cranes, and recently 4000, 7500, and 12000 metric ton capacity cranes manufactured by ZPMC. We design buildings, provide heavy rigging design (Staples Arena), and work on a variety of other structures such as the Liebherr 996, the largest hydraulic excavator in the world. We also design many wharf and pier structures.

Cranes Designed in the 1970s

2 x 6000 t

2 x 7000 t

In the 1970s we provided design work on two large floating cranes.

Both sets of twin cranes were built by AmClyde.

“Left Coast Lifter”
San Francisco Bay Bridge

1700 t

We recently provided design review services for the 1700 t shear leg derrick, which is being used to construct the new San Francisco Bay Bridge. As part of this work we assisted in the structural design.

It is shown here lifting a temporary truss for the main span of the bridge.

The boom heel support is also designed to slide aft for boom storage to reduce the clear height during voyage.

Recent and Future ZPMC Cranes

Boom Length	80 m	95 m	105 m
Capacity	4000 t	7500 t	12000 t
120 t	33	62	100
20 t	200	375	600
2 t	2,000	3,750	6,000
0.075 t	53,000	100,000	160,000

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Recently we have been providing design services to ZPMC, a Chinese manufacturer. The 4000 t and 7500 t cranes have been built and are in operation. The 12000 t crane is planned. We are also working on what will be the largest land-based crane in the world when it is constructed.

It is difficult to get a sense of the size and lift capacity of these cranes. To help, the maximum lift capacity of these cranes is provided in terms of locomotives, tractor trailers, pickup trucks, and people.

4000 t Hook

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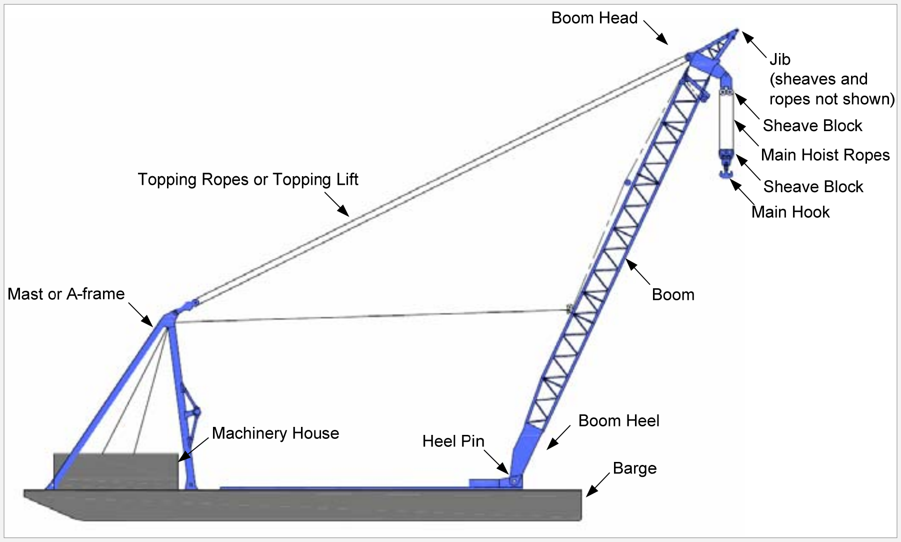
This slide is provided to help get a sense of the size of the crane.

Terms



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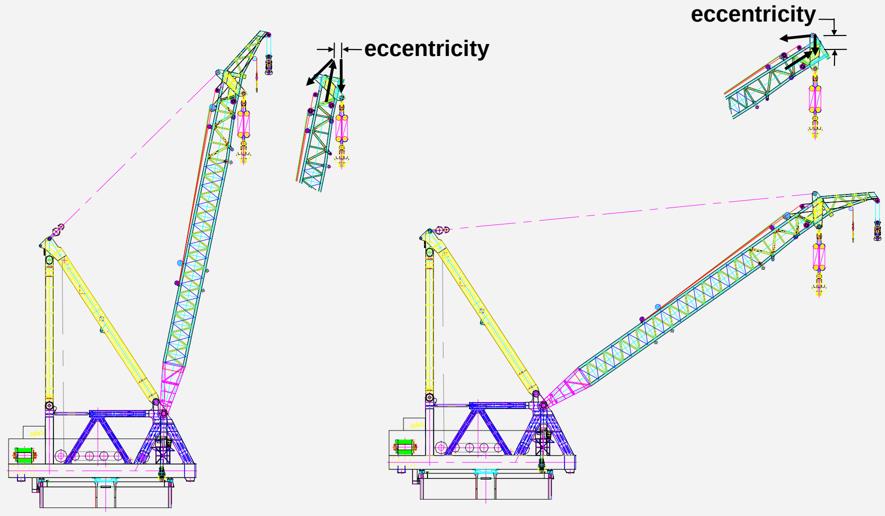
Some terms commonly used in the industry are provided.

A jib is a hoist that is much lower capacity than the main hoist that operates at a much higher speed. A jib is provided for smaller lifts and to assist handling the bigger rigging components of the main hoist.

Design – General Layout



One of the first steps in the design of the boom system is to determine the general layout considering clearances and load eccentricities.

Reeving

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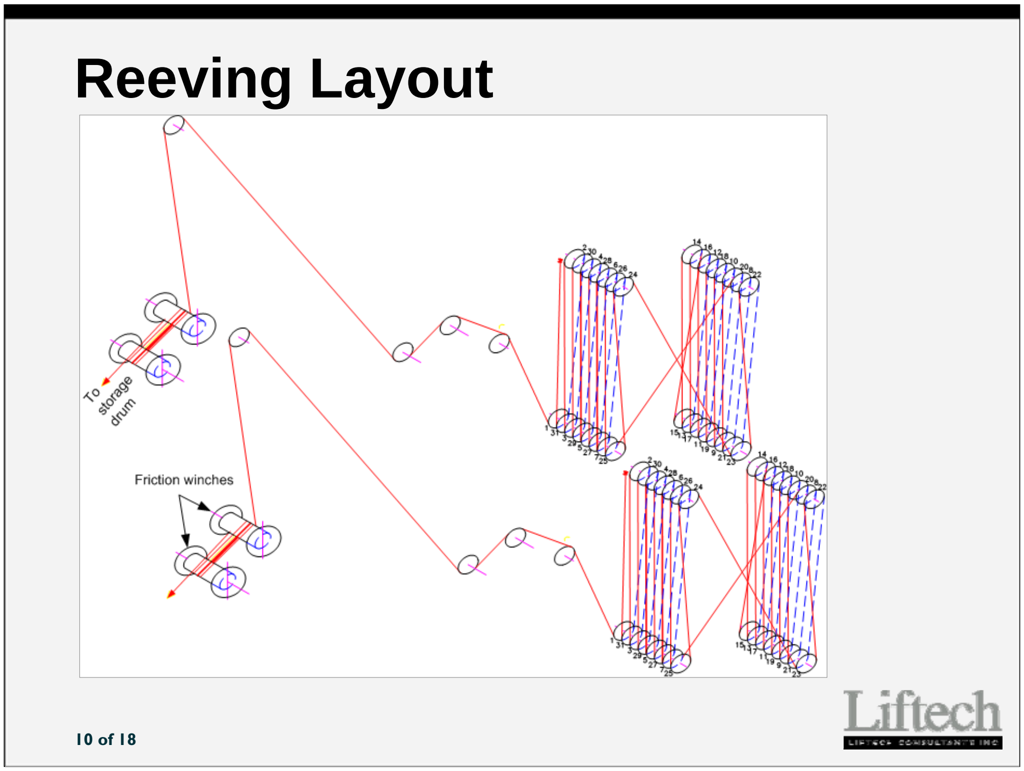
Reeving is a significant consideration with respect to the rope size required. The selection of rope size and parts will affect the sheave sizes including widths and diameters, and the drum sizes.

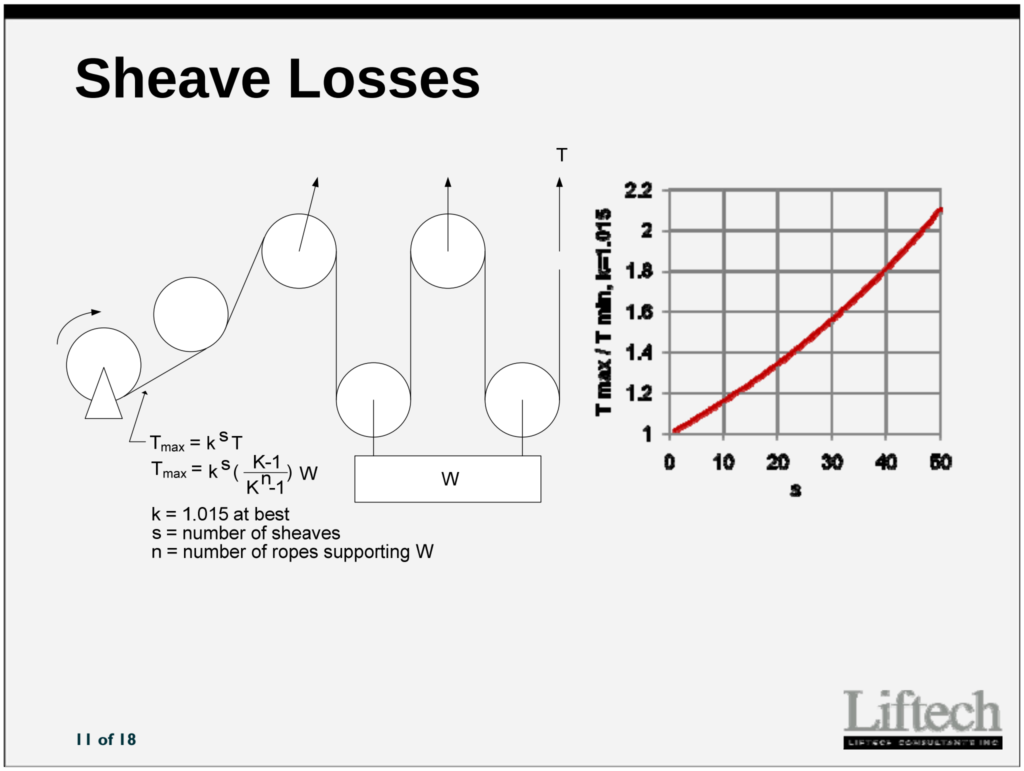


Typically two independent or nearly independent rope systems are provided for the topping and hoist systems.

Friction winches and storage drums are commonly used. Not having tension on the stored rope permits multiple wraps on the storage drum and a constant hoisting torque regardless of the rope stored on the drum.

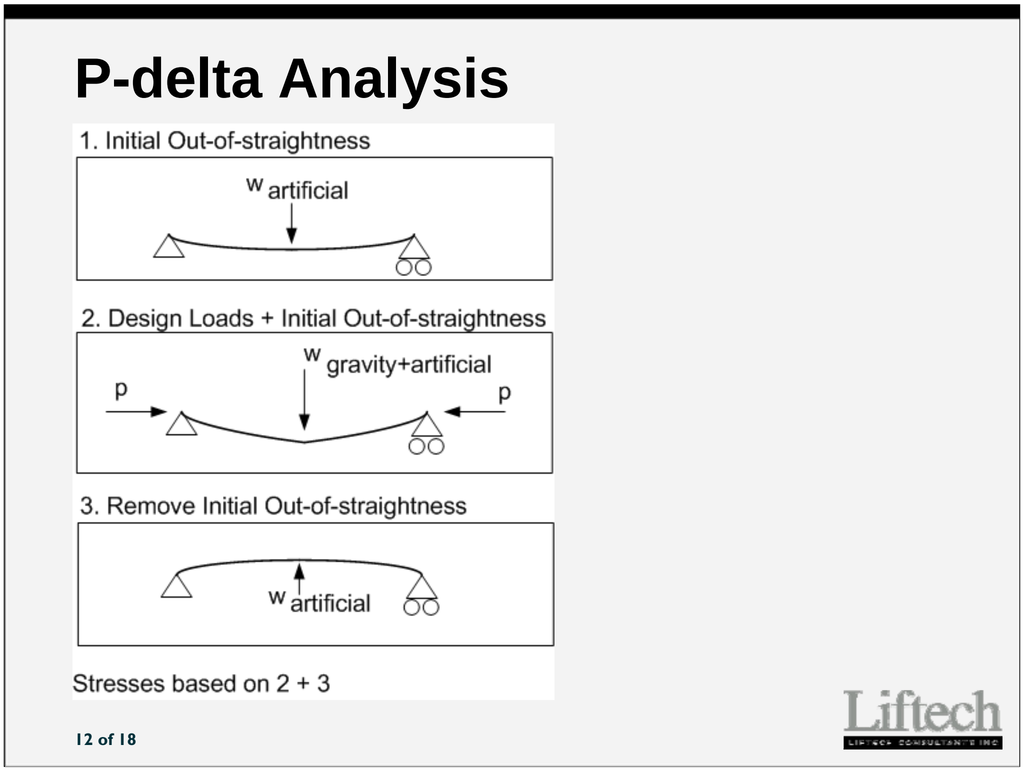
Notice the reeving sequence between the sheave blocks. The sequencing is selected to balance the rope tensions on the blocks and limit the eccentricity of the rope resultant. An excessive eccentricity will result in the blocks rotating and the ropes not seating properly in their sheaves.

The tensions in the parts of rope vary due to the sheave loss or friction loss in the sheaves as discussed next.



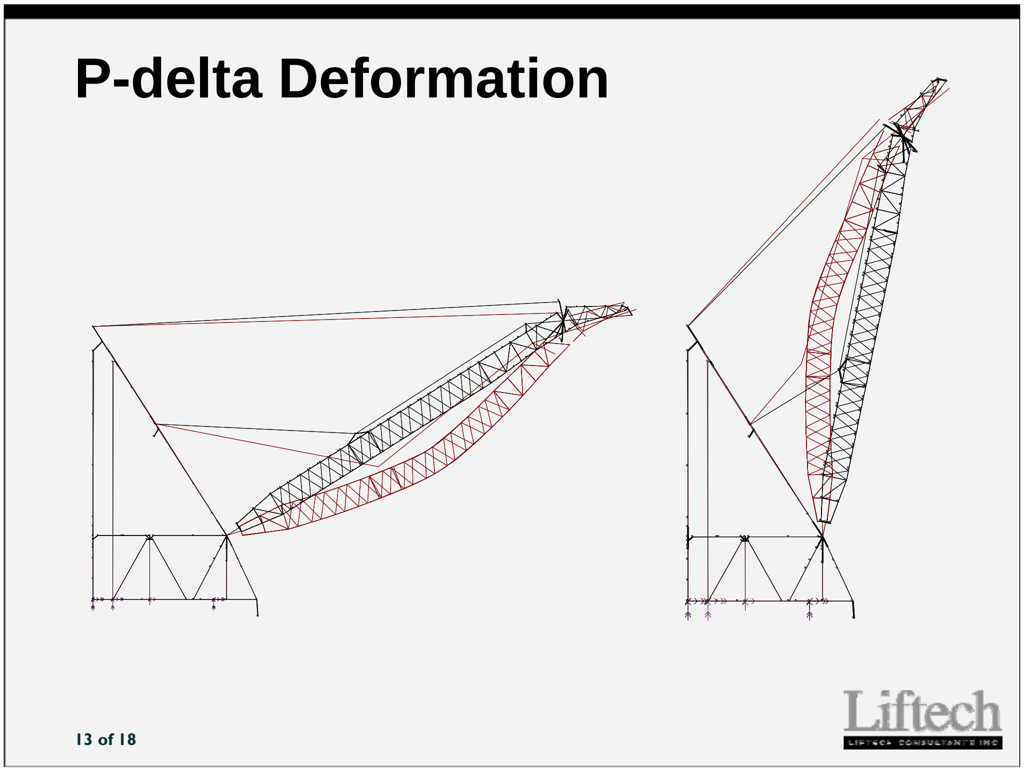
In selecting the rope sizes and the reeving layout, the sheave loss is important. Due to the friction force between the sheave and pin, when a rope is pulled around a sheave, it will typically have 1.5% more tension.

Using a smaller rope size has many advantages, in particular handling and sheave diameters. Typically 20 to 32 sheaves will be used in each rope system.



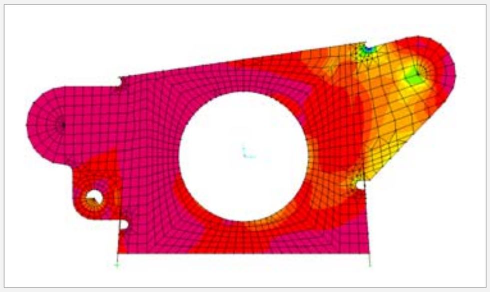
In the design of the large crane boom structures, because reducing weight is a major goal it is worthwhile performing a P-delta analysis that accurately accounts for the initial out-of-straightness of the fabricated boom structure.

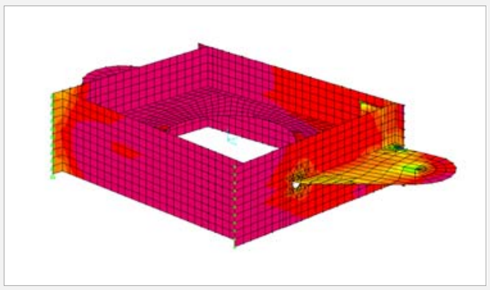
To simplify the analysis, artificial loads are applied that provide a boom that is deformed in the most severe geometry allowed by the fabrication requirements. A P-delta analysis is performed that includes the artificial loads and design loads. The calculated stresses considered are those from the analysis including the design and artificial loads less those calculated from only the application of the artificial loads.



Exaggerated deflected shapes from P-delta analyses are shown here for the global boom structure.

Optimizing





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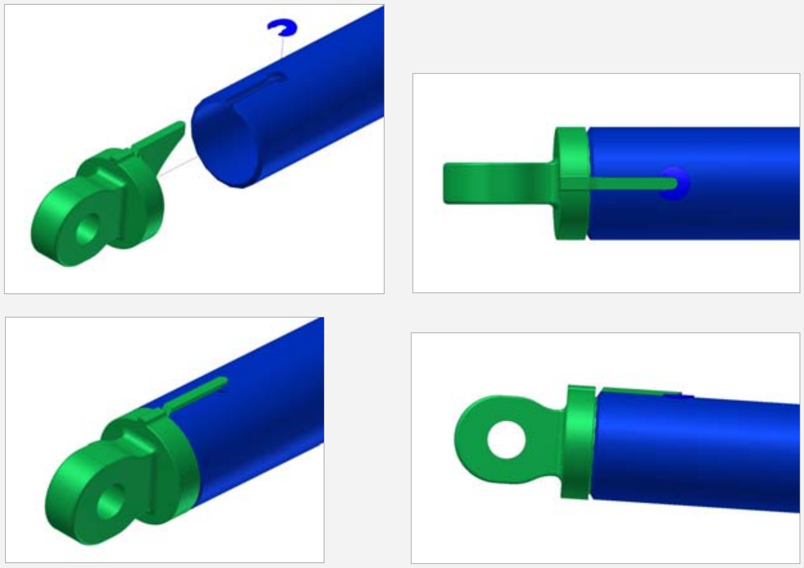
To limit the weight in the boom structure, detailed plate finite element analyses are made of structural components. Although fatigue is not a significant concern, fatigue tolerant details are used to limit localized stresses.

Fabrication and Erection



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Constructability is a major design issue. Castings are commonly used for connections, particularly when the cranes are fabricated in high labor cost locations, and where many pinned connections are required for cranes that will be assembled and disassembled multiple times during their working life.

Castings are most worthwhile for complex fittings, large fittings that would require a lot of welding, and when a large number of the same casting can be used.

Welding

Material Fy	Weldability	Comment
50 ksi	No issues	Rarely used on boom
70 ksi	Some issues	Often used
80 ksi	Some issues	Most common
100 ksi	Problematic	Strict procedures required

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Welding is a major fabrication issue because high strength steels are commonly used, particularly for the boom structures. Steels with 70 and 80 ksi yield strengths are commonly used. These steels require some additional effort in welding than the 50 ksi yield and lower strength steels.

One hundred ksi yield strength material is also used. There have been many fabrication problems with these materials. If the welding requirements are diligently followed, and proper weld procedures are followed, these problems can be avoided.

Thanks

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Quality Assurance Review:

Author: Erik Soderberg

Editor: Michael Jordan / Khoa Pham

Principal: Erik Soderberg

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