The Effect of Ultra Large Container Vessels on Cranes and Infrastructure

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PORT&TERMINAL Technology

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Overview

Section 1: Vessel Changes

Section 2: STS Crane Requirements

Section 3: Infrastructure Requirements

Section 1:
Vessel Changes

Ultra Large Container Vessels

CMA CGM Benjamin Franklin at Port of Long Beach

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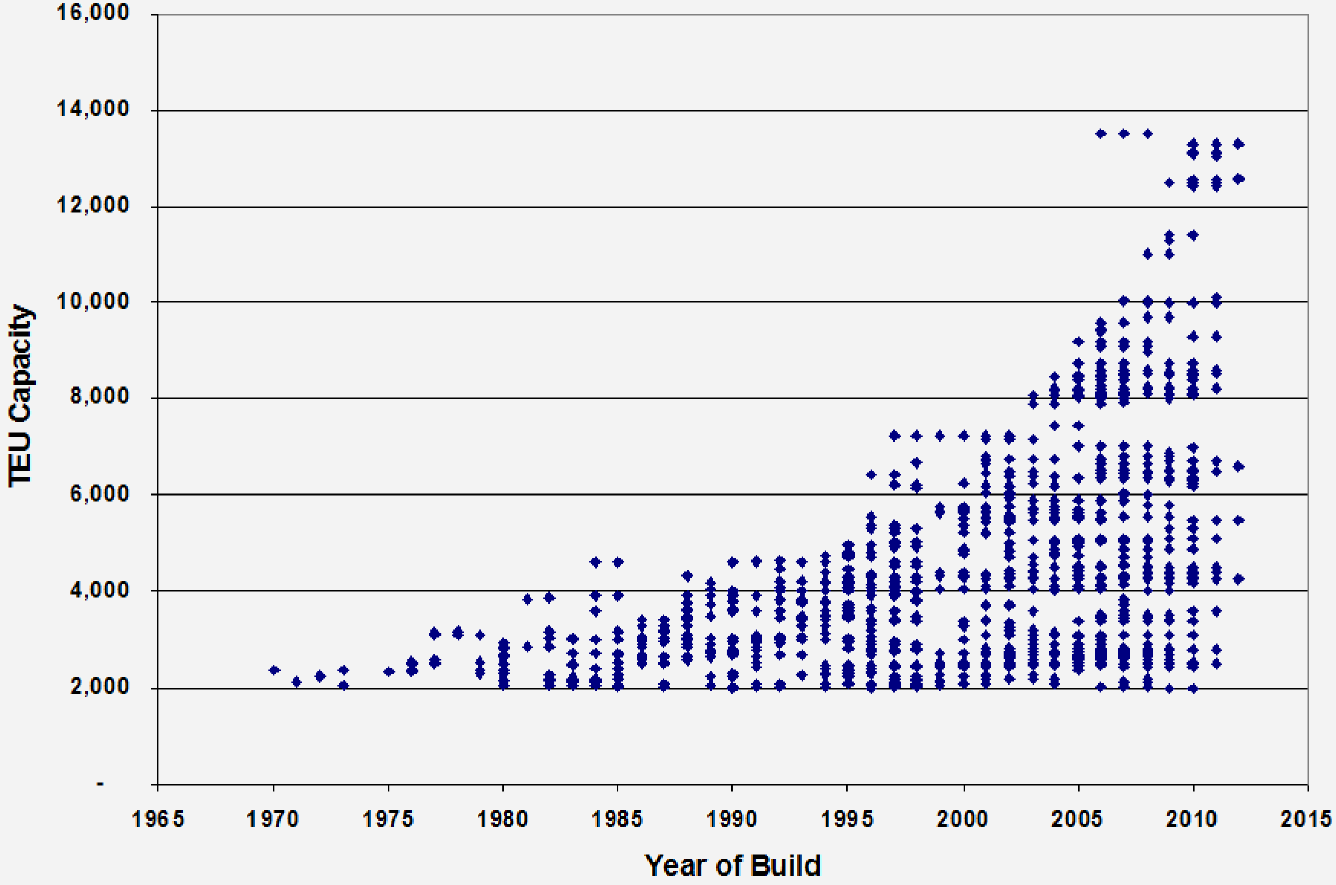
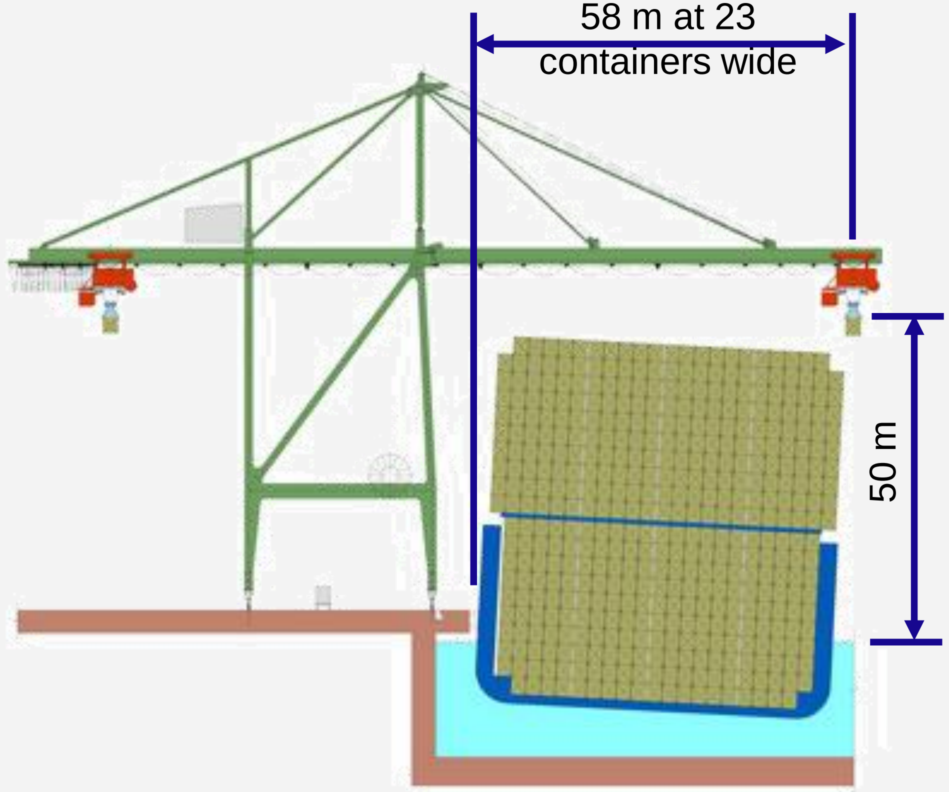
Ship Size Growth



Section 2:
STS Crane Requirements

ULCV Crane Requirements



Notes:

1. Outreach based on 1 degree list and 1 m trolley overrun.
2. Lift dimensions depend on operations; amounts shown are approximate. Dimensions shown are based on: 8.5' tall top box with 1' clear, 1 degree list, and 12.5 m of draft.

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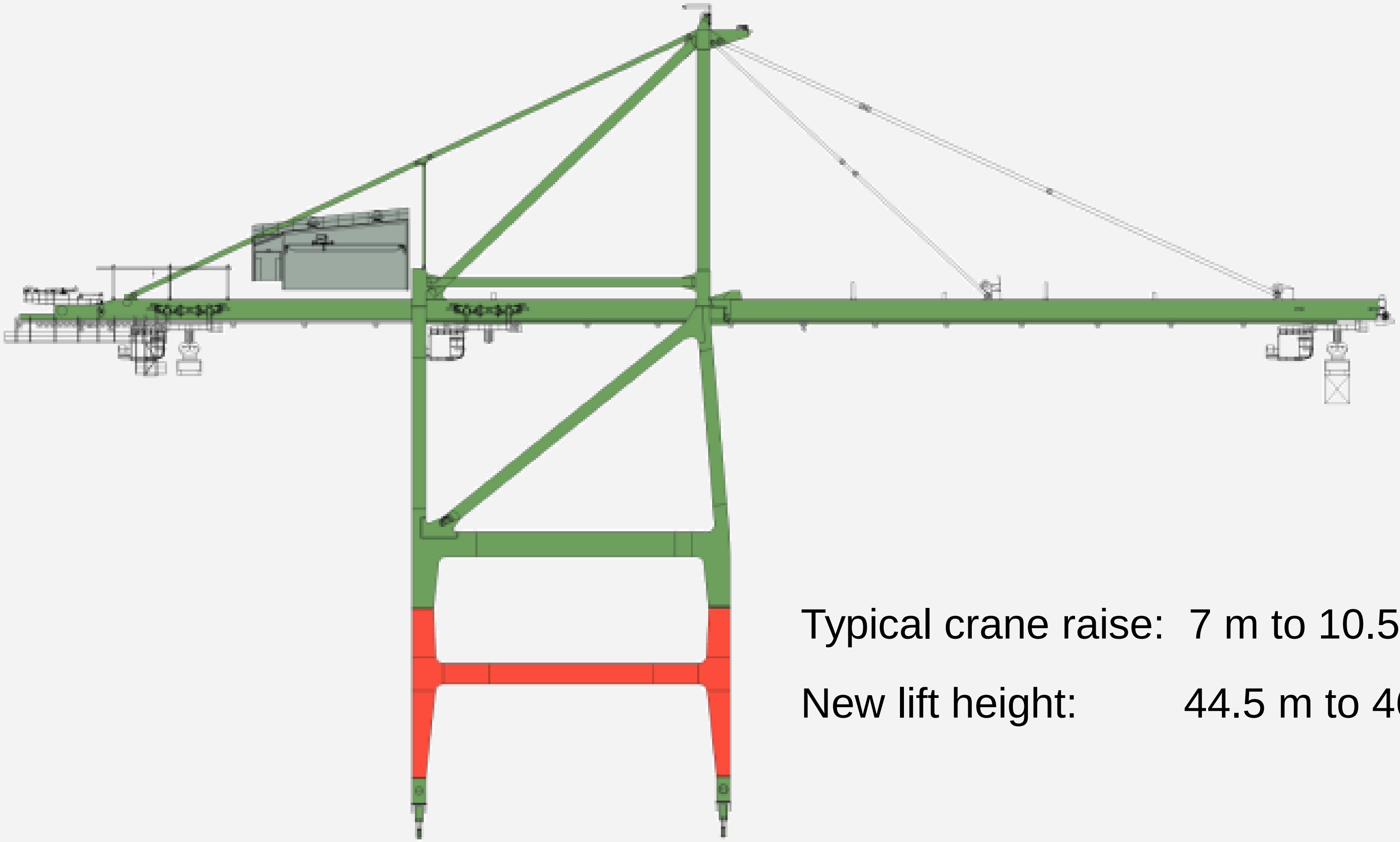
Crane Raising on the US West Coast



Typical crane raise: 7 m to 10.5 m

New lift height: 44.5 m to 46.5 m

Crane Raise with Jacking Frames

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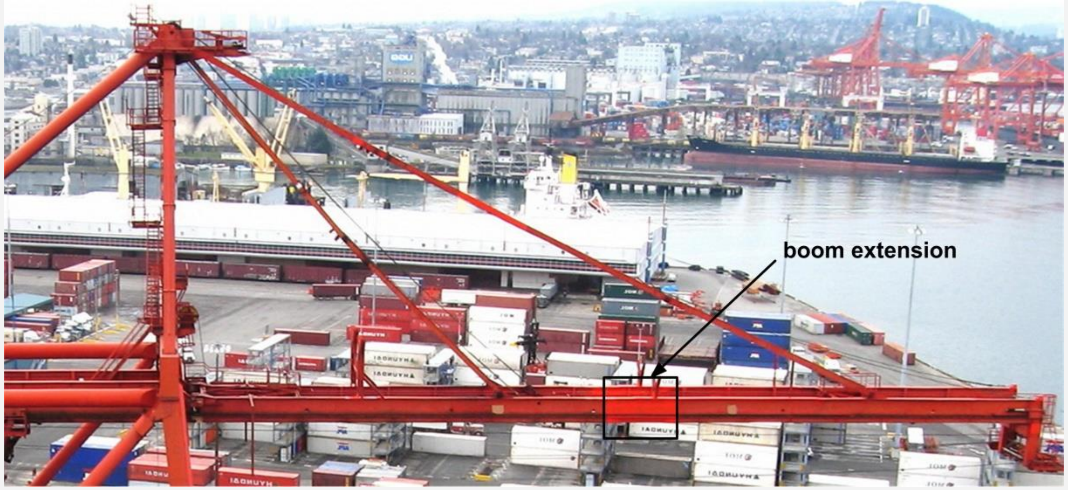
Crane Modifications - Some Considerations

1. Design ship
2. Stability, ballast, and wheel loading/girder capacity
3. Construction impact to terminal operations
4. Electrical system upgrade?
5. Seismic upgrade?
6. Main hoist drum - rope capacity
7. Boom hoist lift capacity
8. Other – see speaker notes



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Cost to Modify Existing Cranes

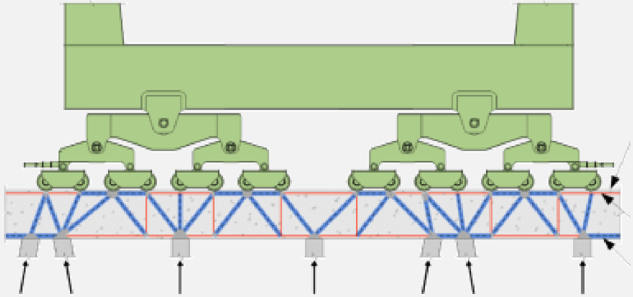
Cost can vary significantly depending on:

- Scope of structural modifications
- Location and local labor
- Scope of mechanical and electrical modifications such as rope drums, trolley cable reel, machinery house service cranes, cabling, lighting, access ways, new wire rope, etc.

Estimated cost per crane for short raise with low labor cost – around US$1.5M

Estimated cost per crane for tall raise with boom extension and high labor cost - US$4-5M

Section 3: Infrastructure



Berth Space

ULCV lengths are not much longer than the previous generation.

Some berths require additional length – a costly option.

Less costly – install more compact crane stops closer to wharf end, add a mooring dolphin beyond the wharf *(see next slide).*

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Mooring Dolphin

Add a mooring dolphin beyond wharf so the vessel can be located closer to the end of the wharf.

Mooring Dolphin at IMTT Port of Richmond

Berthing Fenders

UCLV berthing velocities and angles are typically much less than those in traditional design guidelines.

Consider recent data when determining berthing energies.

A cost-benefit analysis may justify the acceptance of existing systems.

Bollards

Increased mooring forces may require higher-capacity bollards. Installing higher-capacity bollards requires relatively little cost unless the wharf structure needs strengthening.

Consider site-specific wind speeds and directions when determining required bollard capacities.

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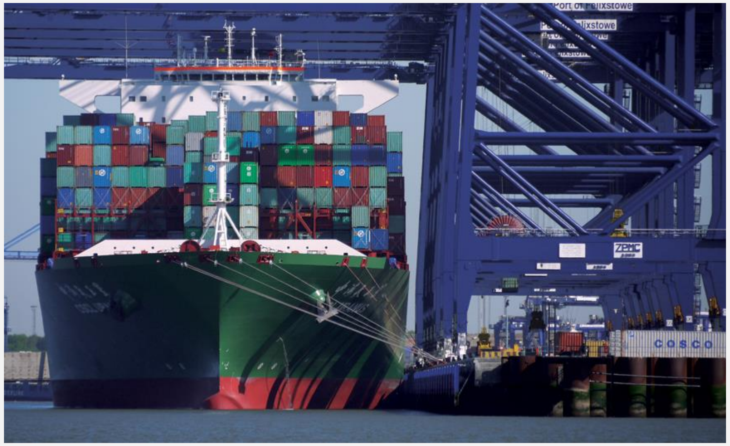
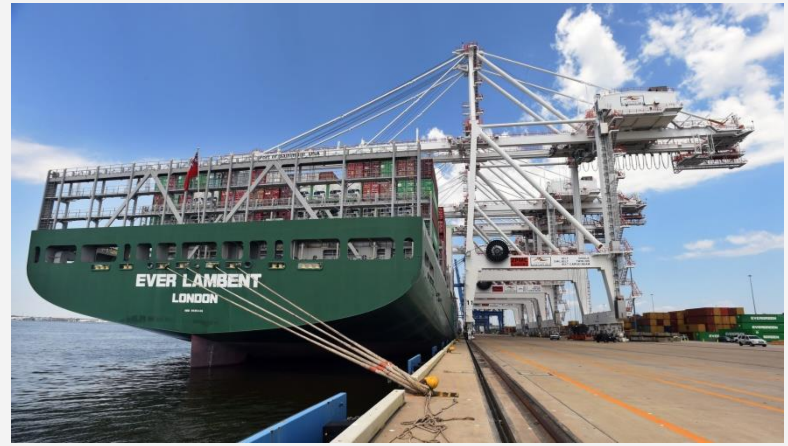
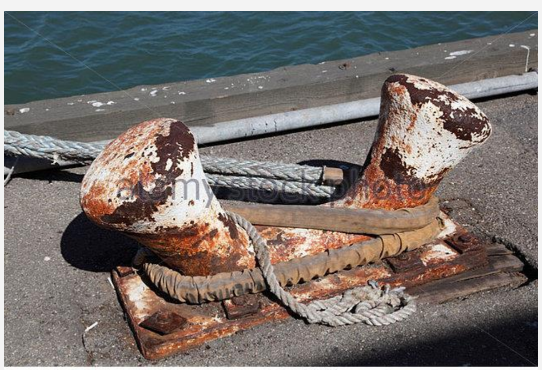
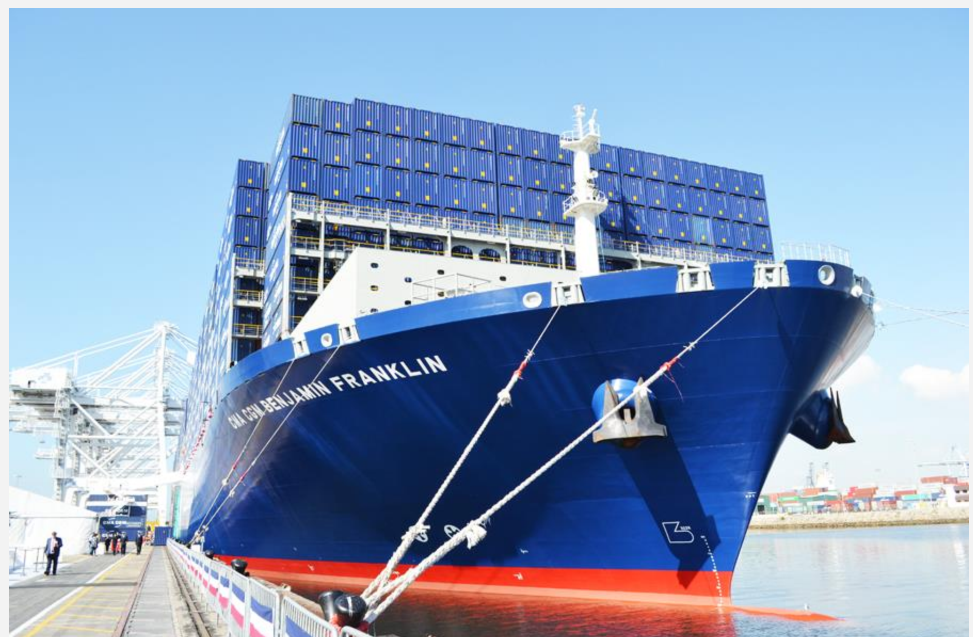
Arrangement and Bitt Loading









Wheel Loads

Wheel loads may exceed the design or rated capacity of existing wharf girders.

Options to address excessive crane loads include:

- Optimize crane design
- Analyze or load test structure & foundation *(see next slide)*
- Strengthen existing girders
- Replace girder systems with new, stronger systems
- Increase crane rail gage for new cranes

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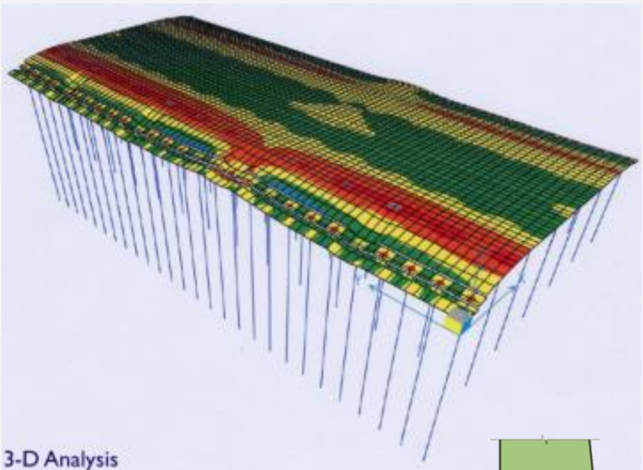
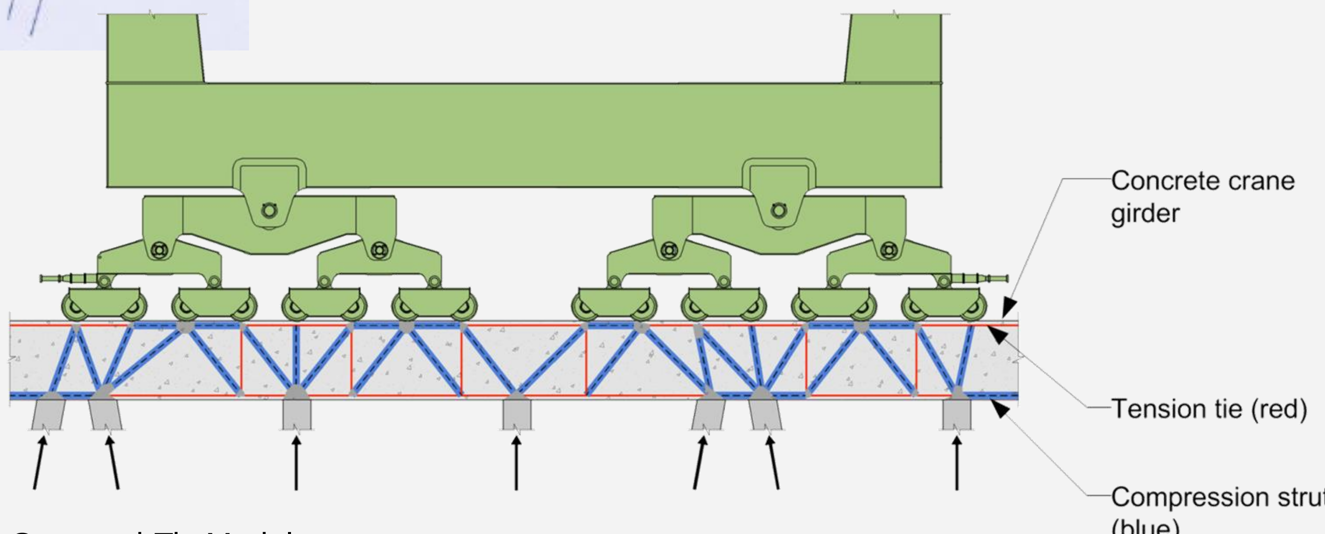
Justify Increased Rated Girder Capacity – Girder Strength





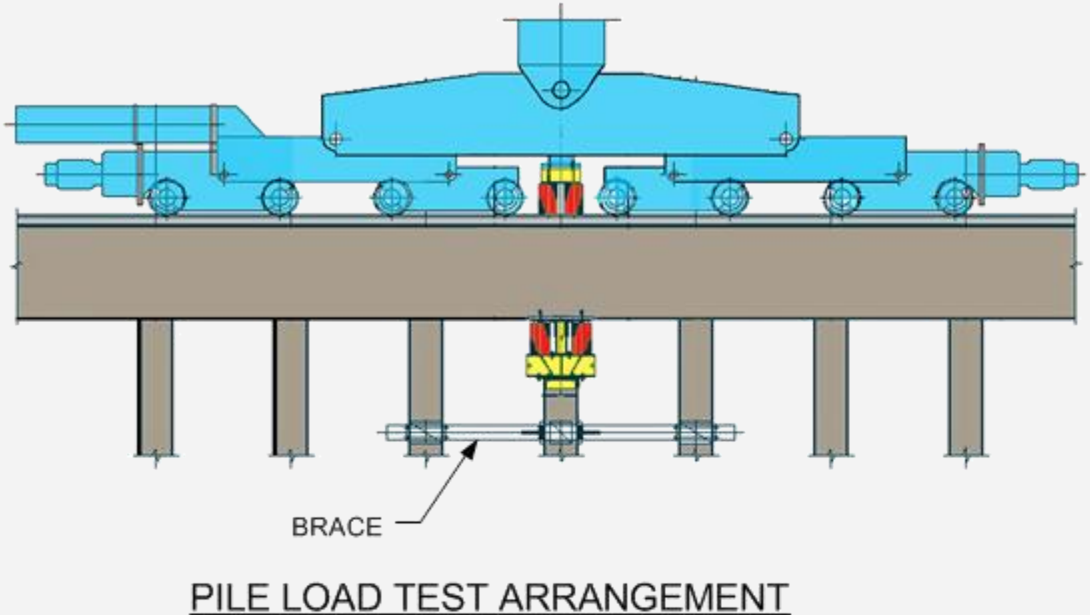
Strut-and-Tie Model

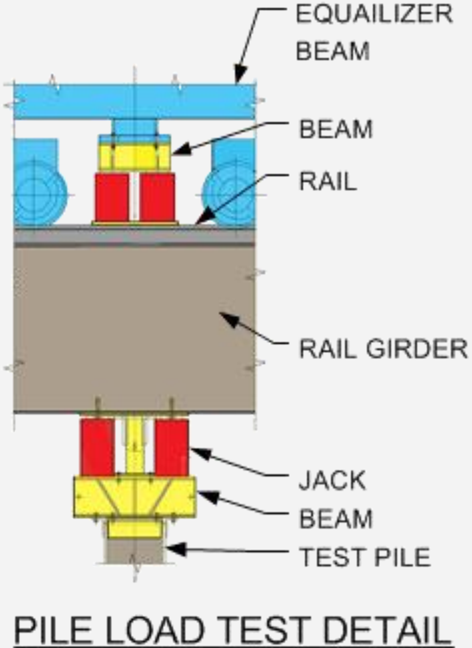
Justify Increased Rated Girder Capacity – Piling Capacity

Analyze pile driving records

Pile dynamic analysis through testing

Load test





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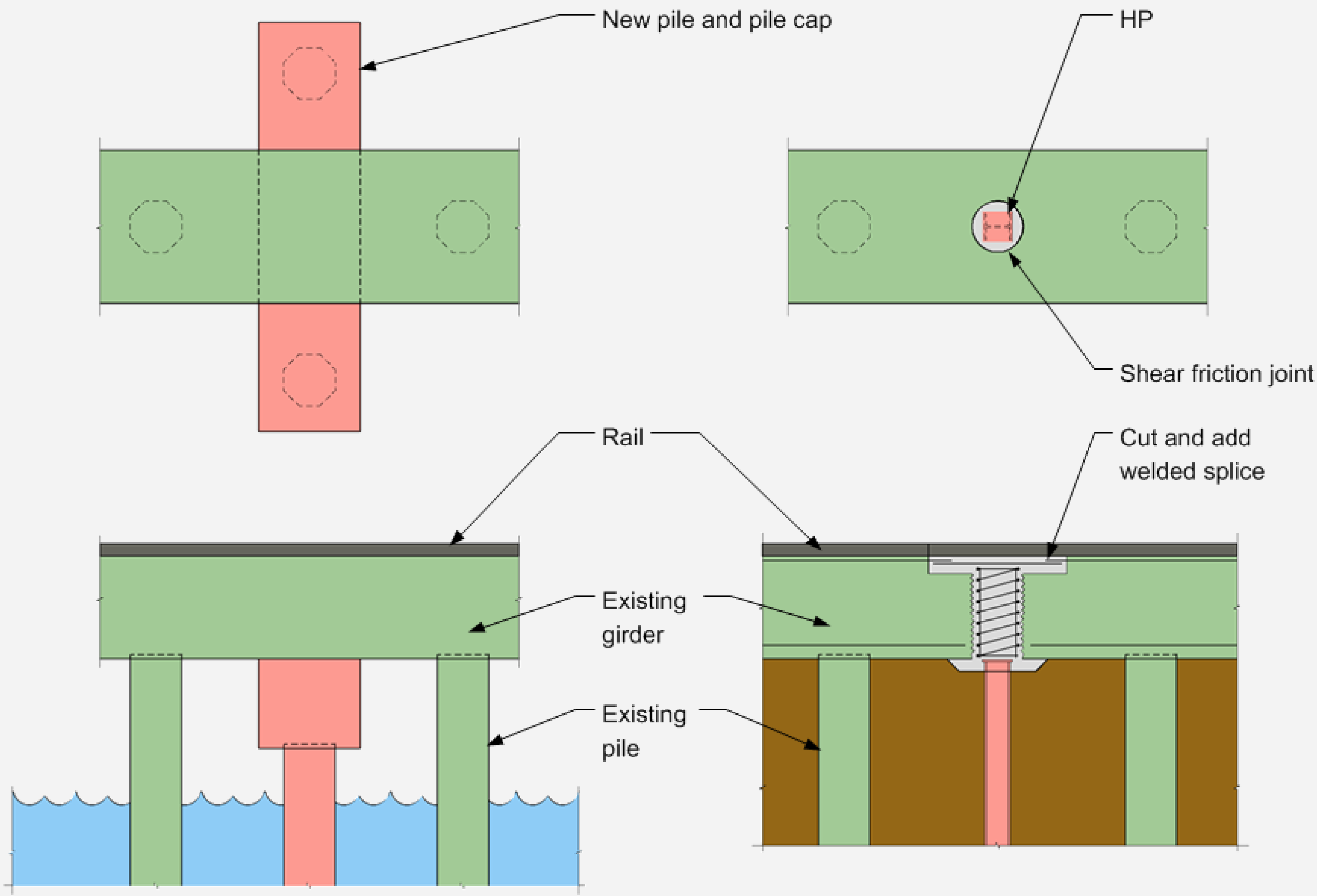
Crane Girder Strengthening



Header beam with two piles

Pile through girder

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Summary

ULCVs affect STS cranes and wharf infrastructure.

STS cranes outreach 23 containers wide, 58 m from fender face.

STS lift height above high water about 50 m.

Increased vessel lengths are limited but may be significant. Consider low cost modifications such as new and relocated crane stops, mooring dolphins beyond wharf.

Fenders for smaller 12,000 TEU range vessels may be adequate.

Increased mooring forces may require larger bollards. Costs are limited unless wharf strengthening is required.

Consider performing a crane girder study to justify additional capacity before strengthening or replacing.

Consider performing a study to determine your terminal requirements and the most cost effective approaches.

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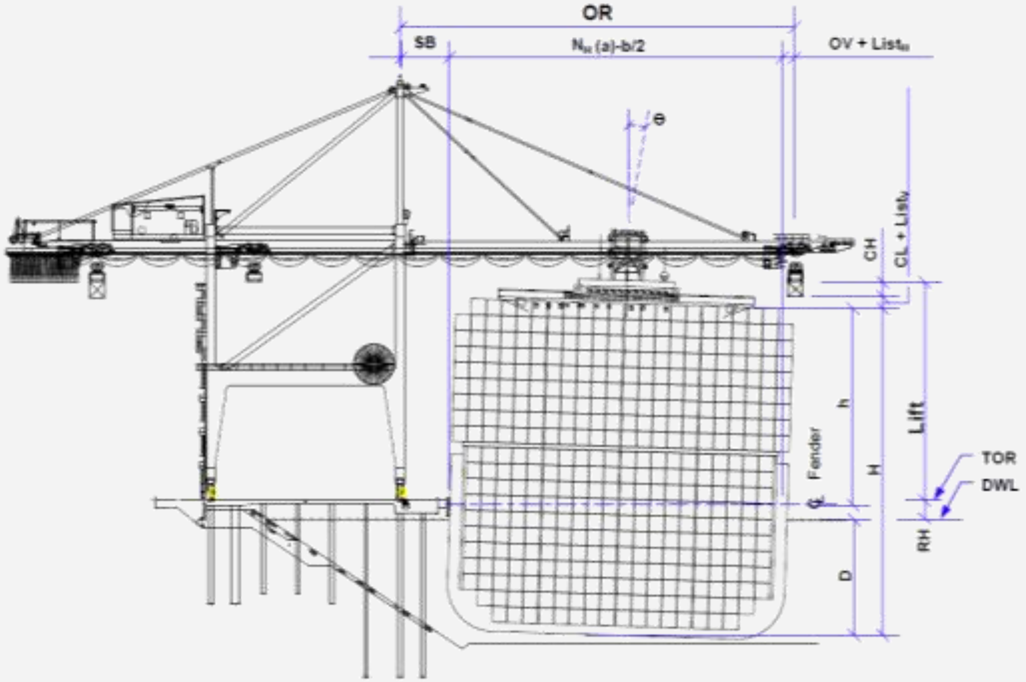
Container Crane Outreach and Lift Height Guidelines

Version 1 November 2013



Approximate Outreach

			2.0	4.0	6.0
		SB, m	2.0	4.0	6.0
		θ, deg	1.0	1.0	1.0
		OV, m	1.0	1.0	1.0
N_H	a x n, m	h, m	Outreach, m		
13	32.5	30.0	34.8	36.8	38.8
14	35.0	32.9	37.4	39.4	41.4
15	37.5	32.9	39.9	41.9	43.9
16	40.0	32.9	42.4	44.4	46.4
17	42.5	35.8	44.9	46.9	48.9
18	45.0	35.8	47.4	49.4	51.4
19	47.5	38.7	50.0	52.0	54.0
20	50.0	38.7	52.5	54.5	56.5
21	52.5	38.7	55.0	57.0	59.0
22	55.0	38.7	57.5	59.5	61.5
23	57.5	38.7	60.0	62.0	64.0
24	60.0	41.6	62.5	64.5	66.5
25	62.5	41.6	65.0	67.0	69.0
26	65.0	41.6	67.5	69.5	71.5

Approximate Lift Height

		RH, m	2.0	3.0	4.0
		θ, deg	1.0	1.0	1.0
		CL, m	0.5	0.5	0.5
N_V	H, m	D, m	LH, Lift Height, m		
14	41.4	10.7	32.1	31.1	30.1
15	44.1	11.0	34.5	33.5	32.5
16	46.9	11.4	36.9	35.9	34.9
17	49.6	11.8	39.3	38.3	37.3
18	52.4	12.1	41.7	40.7	39.7
19	55.1	12.5	44.1	43.1	42.1
20	57.9	12.9	46.5	45.5	44.5
21	60.6	13.2	48.9	47.9	46.9
22	63.4	13.6	51.3	50.3	49.3

Variables – for estimating outreach and lift height

a	Average container spacing, typically 2.5 m
b	Average container width, typically 2.44 m (8' 0")
CH	Container height of top container, typically 2.59 m (8' 6")
CL	Clearance between top of top container and lifted container
D	Draft, see Approximations Note
DWL	Design water level elevation
h	Height from fender centerline to top of top container
H	Height from keel to top of containers without list
Lift	Lift height above top of rail (TOR) = H + CL + CH + (N_H/2) x a x sin Θ – DD – RH
$List_H$	Horizontal movement of top container due to ship list, approximately h x tan Θ
$List_V$	Vertical movement of outermost top container due to ship list, approximately (N_H/2) x a x sin Θ
N_H	Number of containers horizontally across deck
N_V	Number of containers stacked vertically in hull and on deck
OR	Outreach
OV	Overrun: additional distance to avoid trolley slowdown
RH	Distance from TOR to DWL
SB	Setback, the typical range is from 2 m to 6 m
Θ	Ship list design angle, degrees
TOR	Top of waterside gantry rail

Approximations Note

Approximate values are provided for general understanding. Variables used are estimates based on a variety of projects. Actual values will vary for a particular location, ship, crane, and operation.

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