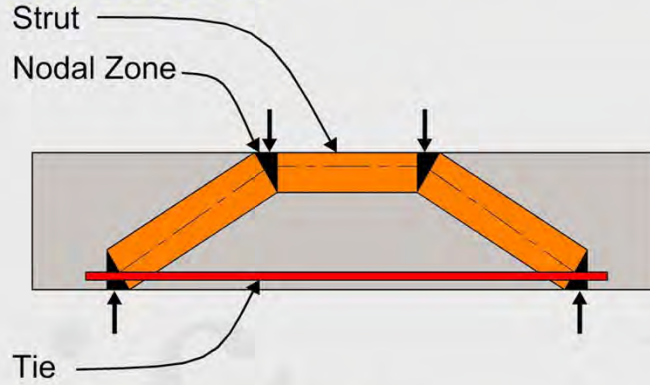


**Ports 2004**  
**Increasing Crane Girder Capacity Using the Strut-and-Tie Method**  
**Method**

## Increasing Crane Girder Capacity Using the Strut-and-Tie Method



**Michael A. Jordan, SE**  
*Liftech Consultants Inc.*

**Derrick Lind, SE**  
*Liftech Consultants Inc.*

**Joe Oakley, SE**  
*Oakley & Oakley Civil and Structural Engineers*

**Thomas Griswold, SE**  
*Liftech Consultants Inc.*

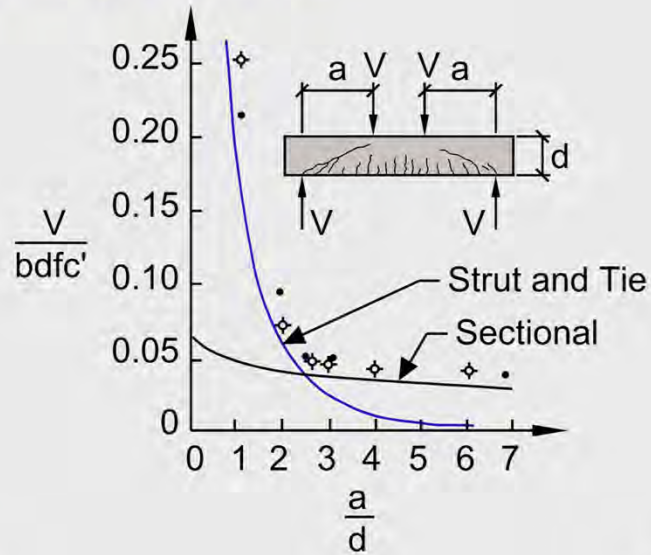
## Why do we want a better solution?

*Cranes are large  
and heavier.*

*It's expensive to  
upgrade.*



## Strut-and-tie method STM is a better predictor



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## STM is only part of the picture

### Acceptable capacity Criteria

*Load combinations*

*Service  
performance and  
ultimate strength*



## **Define Acceptable Capacity**

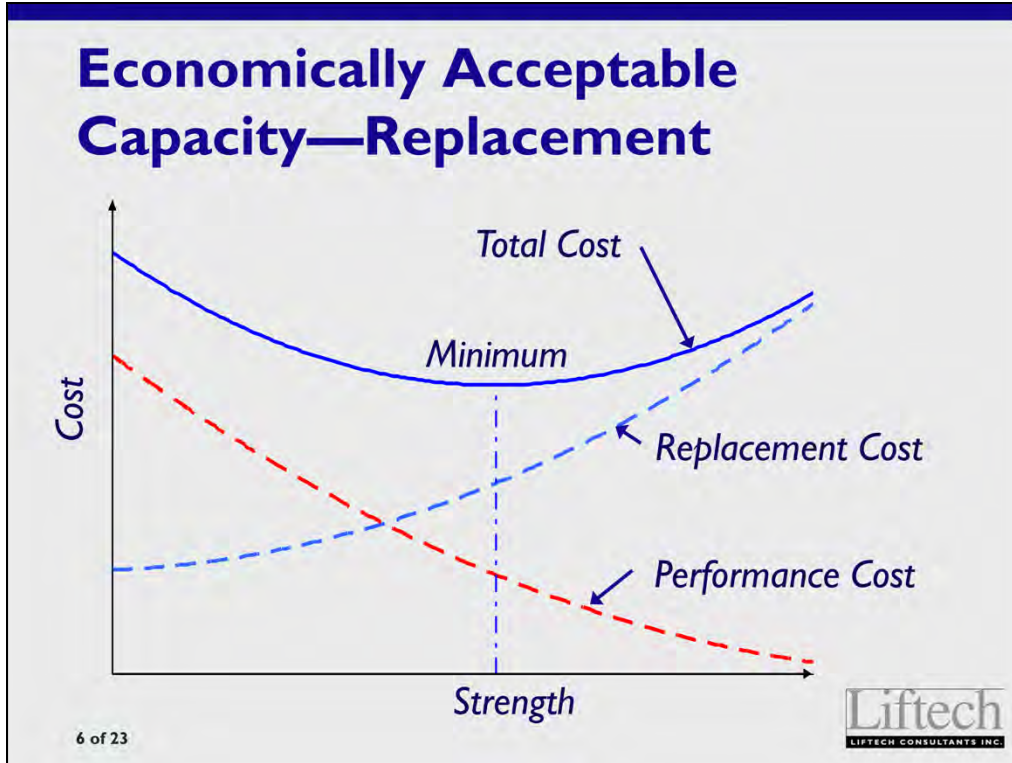
*A reasonable balance between the cost of strengthening and the cost of performance problems.*

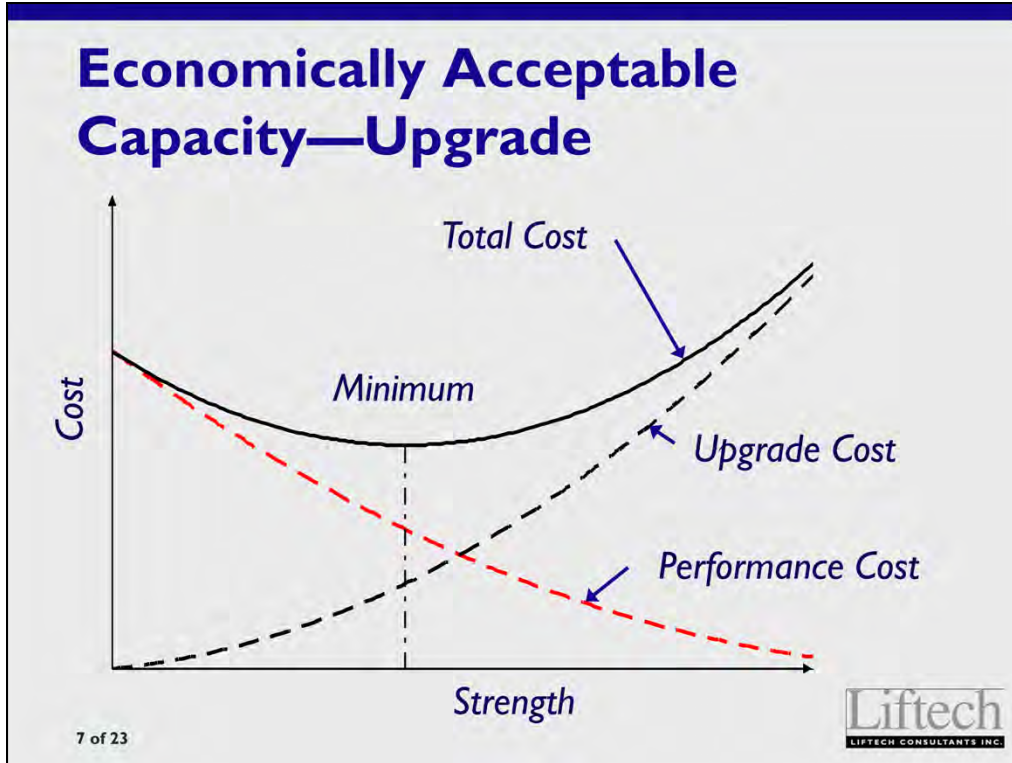
*Layman: “No failures ever.”*

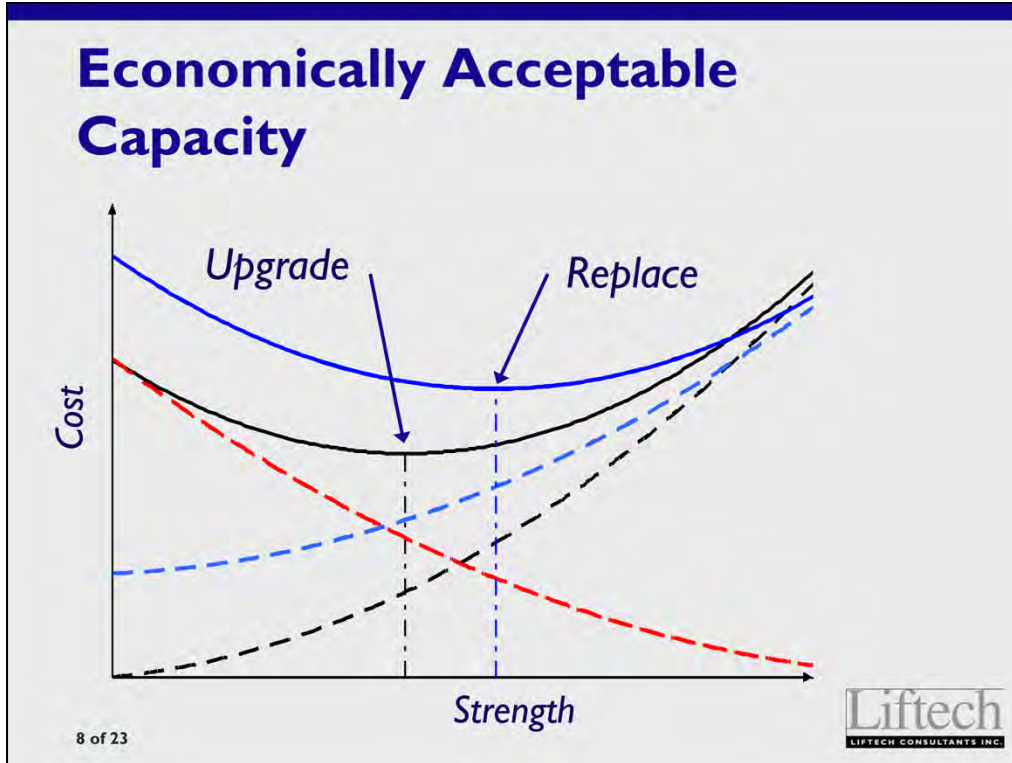
*Engineer: “Acceptable chance of failure.”*

### **See**

*ASCE Seismic Guidelines for Ports*  
*Acceptable Risk Evaluation Procedure.*









## The Proposed Criteria

*Loads*

*Strength*

*Service Limit State (SLS)*

*Ultimate Limit State  
(ULS)*



## Service Limit State Loads

### Dead load:

*All permanent parts—1 400 t.*

*See SEI/ASCE 7-02 3.1*

### Live load:

*Lifted load—60 t*

### Typical SLS load combination:

*1.00 DL + 1.00 LL + 0.50 Impact*

## Ultimate Limit State Loads

**Typical ULS load combination:**

$$1.15 DL + 1.30 LL + 0.50 Impact$$

**Compare ACI-318**

**Existing Structures 20.3.2:**

$$1.19 DL + 1.45 LL$$

## Service Limit State Performance

No local damage

No:

*Excessive cracking*

*Excessive stresses*

*Irreversible strains*

*Microcracks*

## Ultimate Limit States Strength

### Maintain structural equilibrium

*Comparable to earthquake damage*

### Determine Upper and Lower Bounds

*Kinematically admissible velocity field*

*Statically admissible stress field*

### See

*Muttoni et al Design of Concrete Structure  
with Stress Fields*

## Pile Capacity

**A difficult  
problem for ULS**

*Analytical method*

*Load test*





## **Case Studies**

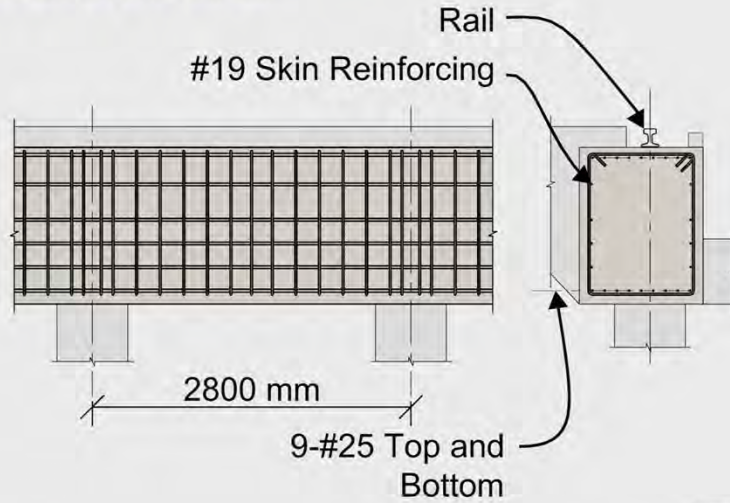
**Port of Oakland Berth 68**

**Virginia Port Authority**  
**Portsmouth Marine Terminal**

Littech

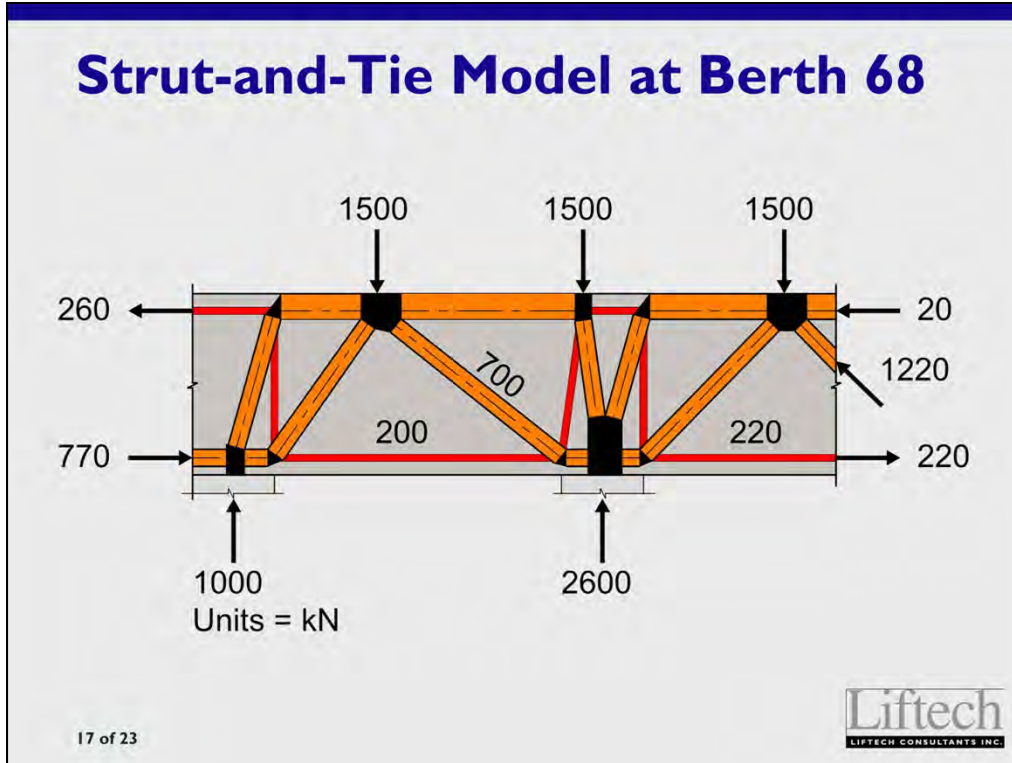
## Port of Oakland Berth 68 Extension

### Waterside Crane Girder





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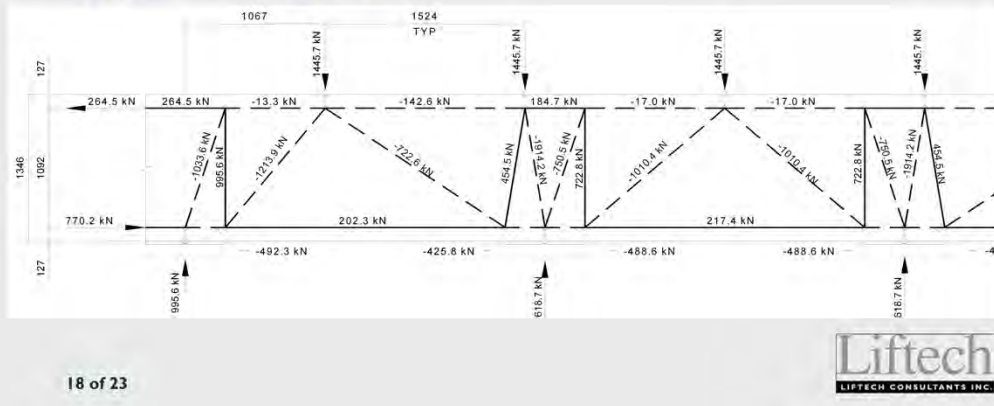
## Results

The STM indicates

*Oakland + 50%*

*Virginia end spans 0%*

*Typical + 20 to 30%*



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## **But What About the Codes?**

### *Load Combinations*

*ASCE/SEI 31-03 Pg 5-2*

*ACI 318-02 Chap 20 Existing Structures*

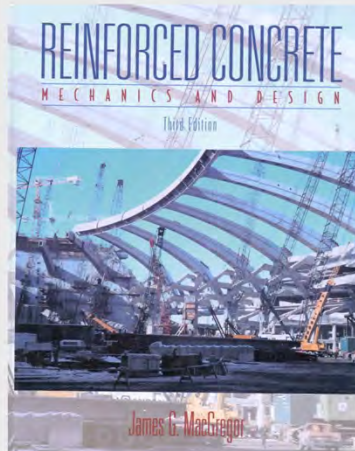
### *Strut-and-Tie Method*

*ACI 318-02 Appendix A*

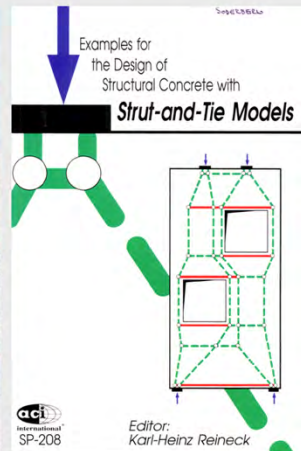
*European Model Code 1990*

## References Worth Reading

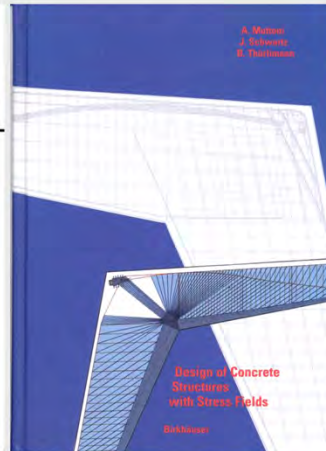
MacGregor



Reineck



Muttoni



## Ideas to Take Home

*STM is a better predictor*

*Acceptable capacity—a balance*

*Two design states: SLS, ULS*



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# Ports 2004

## Increasing Crane Girder Capacity Using the Strut-and-Tie Method

**Liftech Consultants Inc. file data:**

N:\Papers & Presentations\2004 ASCE Ports\_Crane Girder Capacity\_STM\_Final.ppt

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**Quality Assurance Review:**

Author: Michael Jordan

Editor: Derrick Lind

Principal: Michael Jordan