


WJE
Stephen Foster, PE

Assessment and Rehabilitation of Wharf Structures in the Houston Ship Channel



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"Plans are nothing, planning is everything."
-Dwight D. Eisenhower

Outline of Presentation

- Project Overview
- Assessment – "Ask the Structure"
- Analysis – Structure and Service Life
- City Dock 23 – Concrete Repairs and Strengthening

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Port of Houston – Turning Basin & Manchester Terminals




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Project Objectives

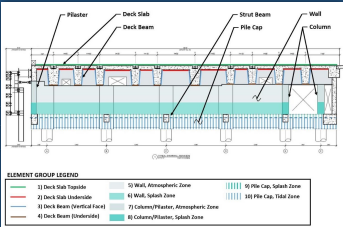
- Wide range of asset ages, construction types, conditions
- Client desired to know:
 - Current condition
 - Potential for increased load
 - Remaining service life



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Wharf Cross-Section



Atmospheric

Splash

Tidal

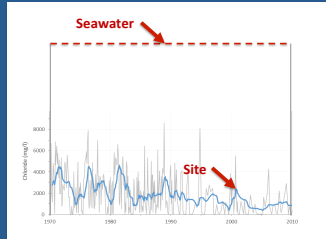
Submerged

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Challenges

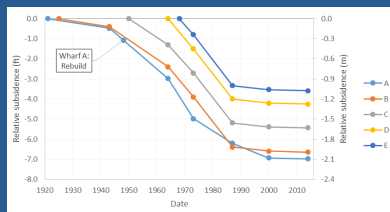
- Slightly brackish water
- Structures 47 to 94 years old
- Subsidence of region



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Subsidence

- 3 to 7 feet of change over 80 years



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"Without data you're just another person with an opinion."

-W. Edwards Deming
Data Scientist

Assessment – "Ask the Structure"


- Approach to Visual Survey
- Mechanical Sounding
- Field Testing and Non-Destructive Evaluation
- Laboratory Evaluation



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Condition Rating

- Good
- Minor
- Moderate
- Severe



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Condition Rating

- Good
- **Minor**
- Moderate
- Severe




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- **Severe**





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Impact and Loading Damage

- Holes in deck
- Cracking in beams

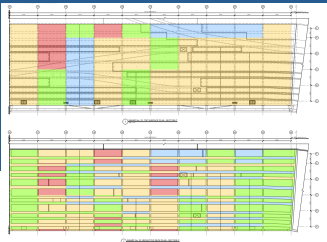


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Condition Ratings

- Sample of deck results



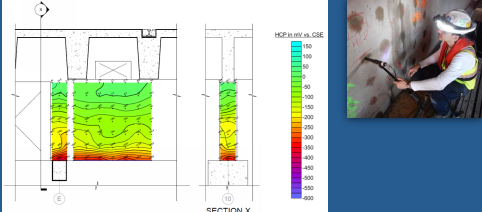
CONDITION LEGEND

- GOOD
- MINOR
- MODERATE
- SEVERE

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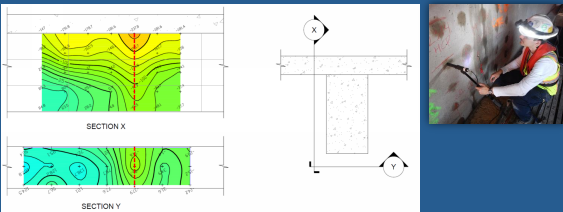
Half Cell Potentials – Wall & Pilaster



The slide features two contour plots labeled 'SECTION X' showing potential distribution in a wall and pilaster. A color scale on the right indicates potential values from 100 to 400 mV vs. CSE. An inset photograph shows a worker in safety gear using a half-cell potential testing device on a concrete surface.

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Half Cell Potentials – Deck Beam

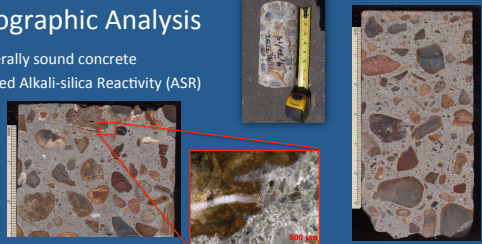


The slide displays two contour plots, 'SECTION X' and 'SECTION Y', showing potential distribution in a deck beam. A color scale on the right indicates potential values from 100 to 400 mV vs. CSE. An inset photograph shows a worker using a half-cell potential testing device on a concrete surface.

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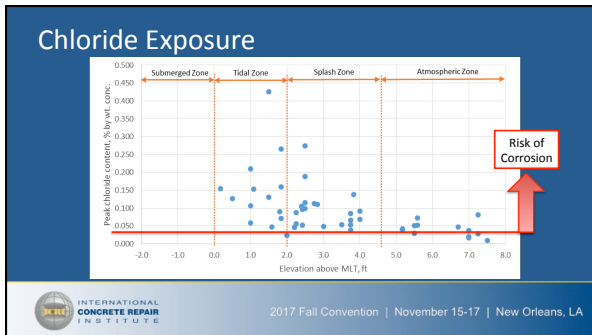
Petrographic Analysis

- Generally sound concrete
- Limited Alkali-silica Reactivity (ASR)

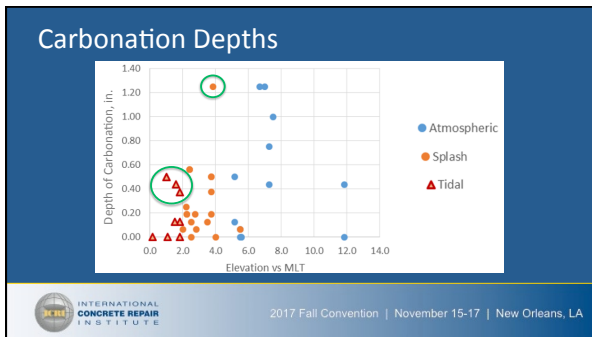


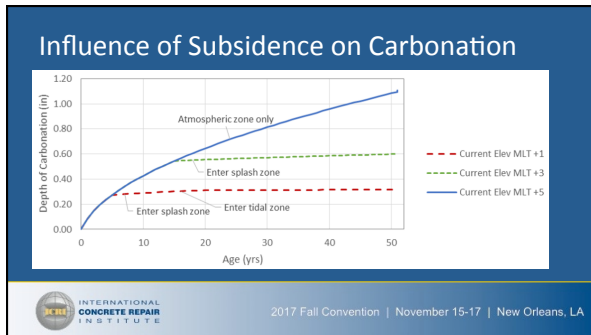
The slide includes three images: a concrete sample with a yellow measuring tape, a large petrographic micrograph showing aggregate and matrix, and a smaller, magnified petrographic micrograph showing a reaction product. A red box highlights a specific area in the magnified image.

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"Analysis is the critical starting point of strategic thinking."
-Kenichi Ohmae
Author, Former Dean at UCLA

Analysis – Structure & Service Life

Load Rating
Service Life Modeling

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Load Rating

- Point Loads
 - 300T Crane
 - Taylor Forklifts
- Distributed Loads
 - 750 psf (original)
 - 1,200 psf (increase)

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Load Rating

Description	Maximum Axle Weight	Wheel Load
Taylor T-650L forklift 65-kip load	141 kips (drive axle)	35.3 kips
300-ton crane self-weight	115 kips (rear bogie)	14.4 kips
300-ton crane 60-kip load	320 kips (outrigger load)	N/A
140-ton crane self-weight	161 kips (rear bogie)	20.2 kips
140-ton crane 40-kip load	187 kips (outrigger load)	N/A



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Load Rating

X - Section satisfactory for lifting
O - Section satisfactory for self-weight (i.e., driving)

Element	Live Load (psf)	T-650L Forklift	Crane	
			140T	300T
Slab	~1,200	O	O	O
Beam A - Typ. Spandrel	>1,200	O	O	O
Beam A - Spandrel	850	O	O	O
Beam B/C - Rail	>1,200	X	O	O
Beam D/E - Typ.	1,050	O	O	O
Beam D/E - End Span at E.J.	900	O	O	O
Bent Walls	>1,200	X	X	X
Drilled Pier	~1,200	X	X	X
Sheet Pile Bulkhead	~1,200	X	X	X

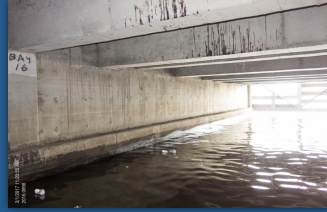
Except at Opening

Some Strengthening Required

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Service Life Modeling

- How long until this...



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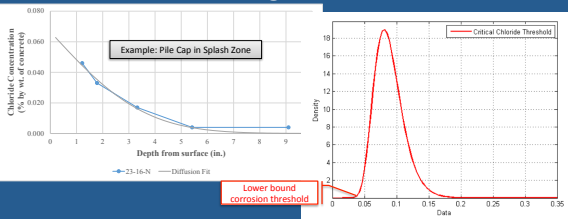
Service Life Modeling

- Becomes this?



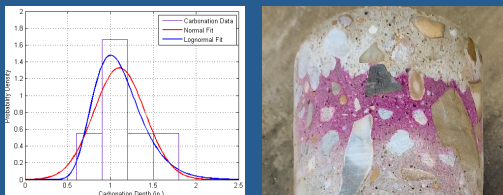
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Service Life Modeling - Chlorides



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Service Life Modeling - Carbonation



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Service Life Findings

- Deck
 - Visible distress + 30% delamination = end of service life
- Strut Beams
 - Background chloride extremely high; 55% with cracking

Element	Percent Damage Predicted in 20 years	Damage threshold	Service Life
Deck Beam	8%	15%	40 years
Walls	14%	30%	> 50 years
Columns/Pilasters	13%	30%	> 50 years
Pile Cap	3%	30%	> 50 years



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"If the statistics are boring, you've got the wrong numbers."

-Edward Tufte
Yale University

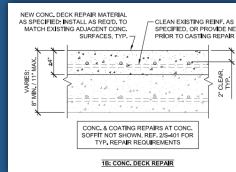
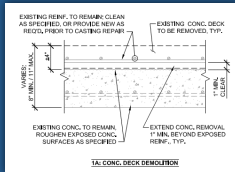
City Dock 23 Rehabilitation

- Deck Topside
- Substructure Repairs
- Strengthening
- Cathodic Protection at Strut Beams




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Deck Topside Hydro Demolition



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Deck Topside Hydro Demolition



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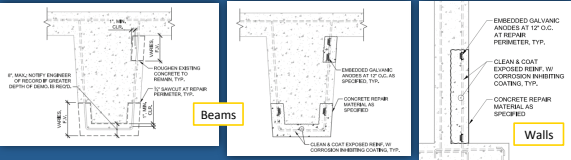
Deck Topside – Horizontal Shear at Repair



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Beam and Substructure Repairs



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Beam and Substructure Repairs



Beams

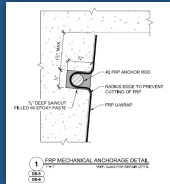
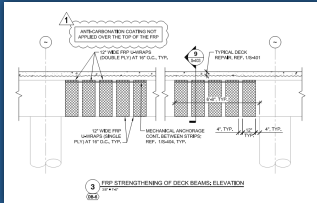


Walls



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Deck Beam FRP Strengthening



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Deck Beam FRP Strengthening



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Summary

1. Condition Assessment
 - ✓ Concrete Inspection & Evaluation
 - ✓ Predicting Service Life
 - ✓ Load Rating
2. Prioritize Based on Assessment Results
3. Repair and Strengthen Accordingly






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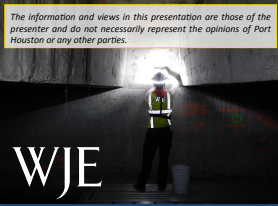
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Thank You – Questions?


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The information and views in this presentation are those of the presenter and do not necessarily represent the opinions of Port Houston or any other parties.



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