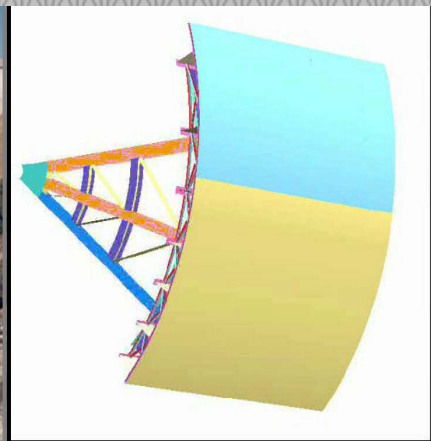
Extending the Useful Life of Existing Navigation Infrastructure

Jackie S. Pettway

Coastal and Hydraulics Laboratory



US Army Corps of Engineers
BUILDING STRONG®

Vision/Background

Drive down long term O&M costs; Increase project reliability

- Economic Assessment Tools
- FEM Database Analysis Tools
- Electronic Information & System Monitoring
- Risk Based Tools for Maintenance
- Asset Management

Extending the Useful Life of Navigation Infrastructure

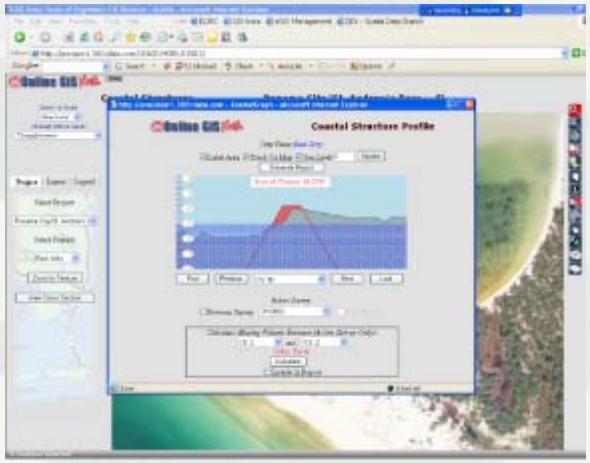
- Improved River Forecasting
- Protective Coatings
- Improved Filler Materials
- Innovative Construction Techniques
- Nondestructive Testing (NDT)
- Structural & Functional Condition Indexing
- Near-field Hydrodynamic Modeling
- Rapid Repair Features

Coastal Structures | Channels & Pools | Inland Structures

Work Package Objectives

Goals

Develop integrated tools, methods, and technologies to extend the service life of aging navigation infrastructure. Drive down O&M costs and increase reliability.



Work Package Objectives

- Leverage military and other agencies' programs infrastructure expertise
- Improve condition assessment techniques and performance capacity predictions (sensing/monitoring)
- Develop rapid repair and alternative construction methods (Innovative Structures)
- Develop non-destructive testing techniques
- Produce new user guidance for repair and maintenance
- Develop decision support tools for planning, operations, risk assessment
- Apply innovative materials, coatings, composites to navigation structure components

Approach / Milestones (Current)

Tasks:	Subtasks:	FY12				FY13				FY14				FY15			
		1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Sensing/ Monitoring	Structural monitoring of miter gates at navigation locks	■	■	■	■	■	■										
	Condition monitoring and predictive maintenance for infrastructure	■	■	■	■												
	Condition assessment of coastal and inland structures , Underwater inspections	■	■	■	■	■	■	■	■								
	Marmet Lock Performance Monitoring	■	■	■	■	■	■	■	■	■	■	■	■				
	Great Lakes Armor Stone Monitoring	■	■	■	■	■	■	■	■								
Improved NDT Techniques and Tool box	Trunnion anchor rod tension measurements and flaw detection	■	■	■	■	■	■	■	■	■	■						
	Multi-strand anchor corrosion detection and service life prediction	■	■	■	■	■	■	■	■	■	■	■	■	■			
Rapid Repair and Replacement using Innovative Materials	Demonstrate use of FRP's at Corps projects			■	■	■	■										
	Lab tests of quoin block sealing and filler materials			■	■	■	■	■	■	■	■						
	Rapid repair methodology					■	■	■	■	■	■	■	■	■	■	■	
	Trunnion anchor rod repair and replacement			■	■	■	■	■	■	■	■	■	■	■			

Approach / Milestones (Current)

Tasks:	Subtasks:	FY12				FY13				FY14				FY15			
		1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q
Decision Support Tools	CSMART – add capabilities for inland nav structures					■	■	■	■	■	■						
	CPT – advance for other infrastructure applications					■	■	■	■								
	LOMA – provide vessel information to lock operators					■	■	■	■								
	FEM - OCA's –AM database linking for life cycle management			■	■	■	■										
	Standardized component designs										■	■	■	■	■	■	
	HSS – criteria for performing fitness for service assessments	■	■	■	■	■	■	■	■								
Engineering Guidance Updates	Lock valve design and replacement guidance							■	■	■	■						
	Position measuring for direct connect hydraulic cylinders				■	■	■										
	Composite material use							■	■	■	■						
	Update technology advancements for infrastructure since REMR		■	■	■	■											

Project Accomplishments To Date

Planned	Status/Accomplished
• Identify demonstration projects for use of composite (FRP) materials.	✓Coordinated, contracted, and ready to install by 4th qtr FY 12
•NDT of post-tensioned trunnion anchor rods: Determine tension and defects in rods.	✓Constructed test bed and initiated laboratory test bed.
•Develop valve repair and replacement guidance.	✓Completed construction of laboratory model for hydrodynamic experiments.
•Present webinar for comparison of quoin block replacement techniques.	✓Completed webinar for replacement technique at Markland Lock – Meldahl Lock delayed
•Develop structural health monitoring system	✓Installed instrumentation for structural health monitoring system
•Users manual for NAVSIMS	✓Version 1 complete by July
•Monitoring Marmet Lock performance	✓Completed lock performance evaluation plan
•Evaluate emerging materials for quoin block sealing and filler materials	✓Obtained quoin blocks for lab tests

Project Accomplishments To Date

Planned	Status/Accomplished
• Update Coastal Structures Management, Analysis and Ranking Tool.	✓Completed geo coding of structures
•Use of FRP sheets for miter gate cracking.	✓Received proposal to evaluate experimental and analytical methods.
•Development of NDT for multi-strand anchors	✓Designed laboratory test bed and initiated construction

FRP Composites Offer Rapid, Durable, Cost-Effective Repairs for Navigation Structures

PROBLEMS

SOLUTIONS

Abrasion

Engineered properties

Durability, corrosion

Quick, easy, durable

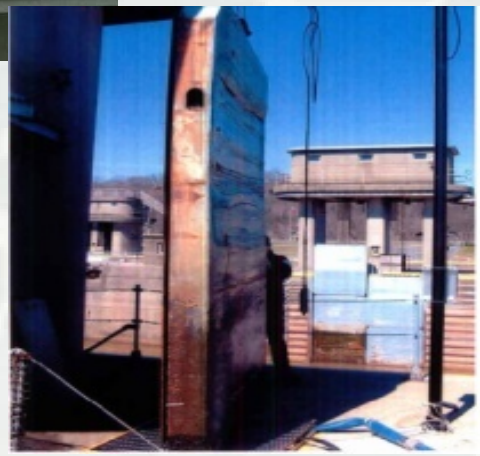
Impact

Materials selection, design

Composite Materials Demonstrations

Spillway Gate Protection

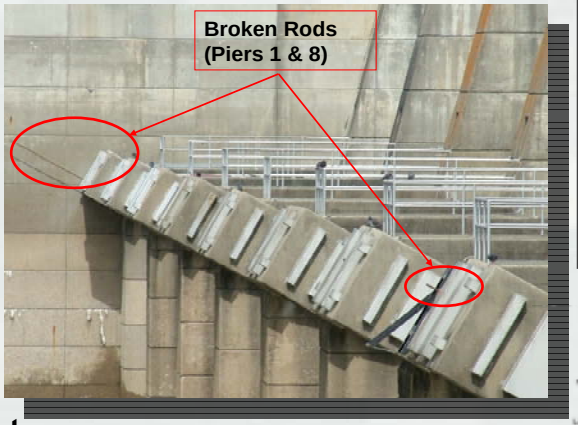
Emergency Gate Repair

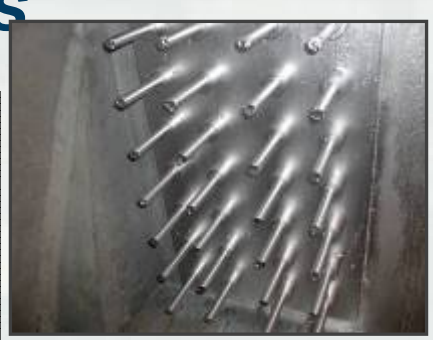


Bulkhead Slot Filler

NDT Measurements of Tension and Corrosion In Trunnion Anchor Rods

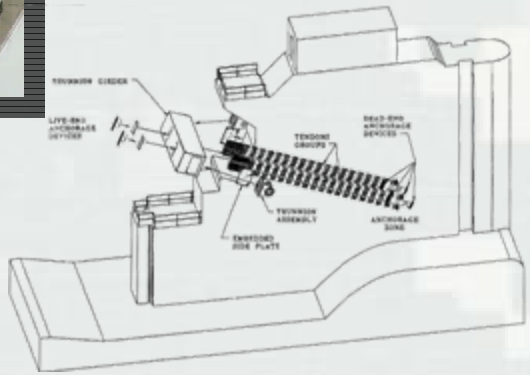
Tensioned steel members can lose tension through fractures, corrosion and slippage of wedge nuts





Objective

Develop NDT methods that directly interrogate the mechanical and material properties of the rods without appreciable risk of damage.

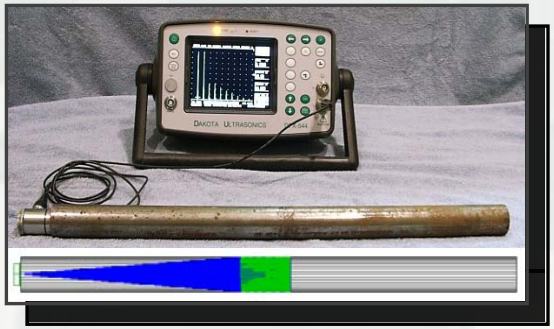


Current Techniques

Ultrasonic acoustics for measuring tension

Non linear acoustics for detecting flaws

- Accomplishments
  - Ability to measure tension in rods ≤ 45’

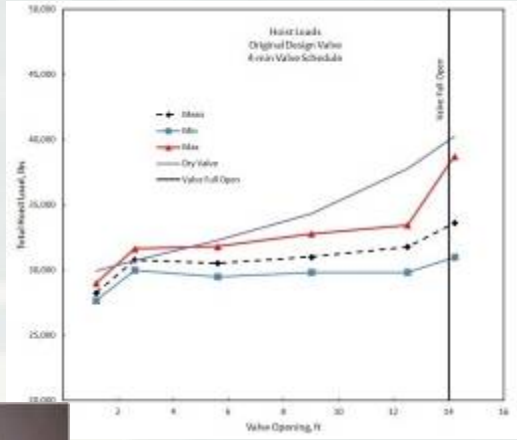


Repair and Replacement Guidance for Lock Culvert Valves

Constructed 1:15-scale physical model to serve as valve testing facility

Measure forces and vibration tendencies of vertically-framed reverse tainter valves

ETL and Technical Reports – design guidance for replacement and rehabilitation of lock culvert valves



Webinar for Quoin Block Replacement

Milling technique
at Markland

Quoin removal at Melhdahl

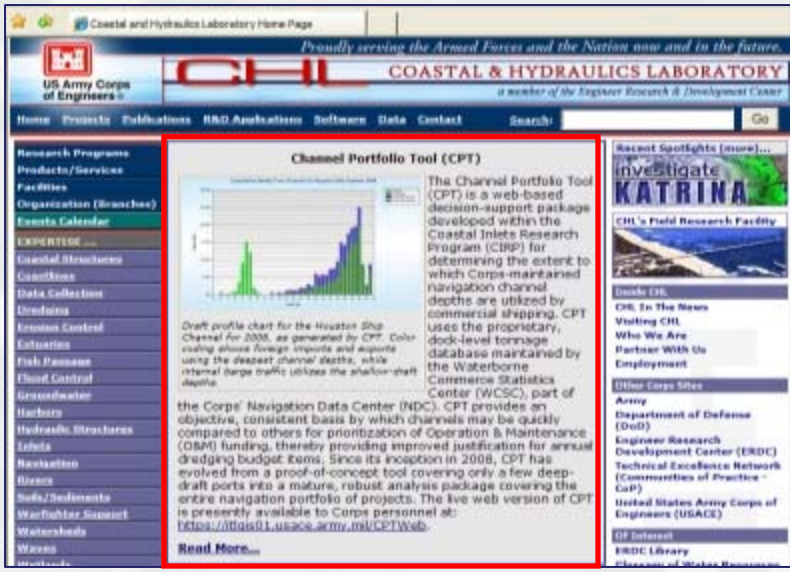
New Techniques to Reduce Miter Gate Cracking

Flexible pintle ball and socket

Channel Portfolio Tool (CPT)

What is CPT?

Web-based application that relates navigable depths to cargo most vulnerable to shoaling. Allows for detailed, reach-level analysis as well as regional and national summaries of the ***waterborne transportation systems*** supported by Corps navigation projects.



https://cpt.usace.army.mil

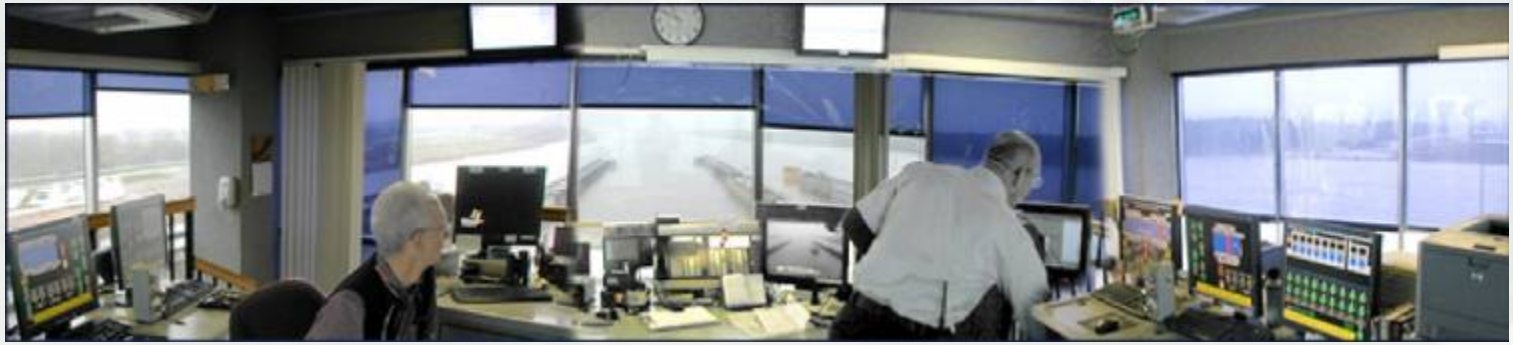
CPT uses data provided by the Waterborne Commerce Statistics Center (WCSC), and is available via the OMBIL portal.

Statements of Need

Improved Justification for and Prioritization of Annual Maintenance Dredging Investments
Tracking Number 2009-N-8

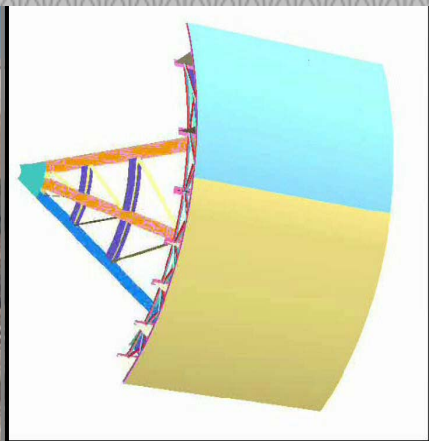
Lock Operations Management Application (LOMA)

- Purpose:
  - Provide end users information needed for decision support
- Goals:
  - Increase lock operator situational awareness
  - Provide vessel operators better information
  - Provide better information to Corps management
  - Exchange information with external users
- AIS is the central LOMA technology



Water Resources Infrastructure Technology

Enable sustainable water resources infrastructure through development and application of state-of-the-art technology and innovative management approaches.



US Army Corps of Engineers
BUILDING STRONG®

Problem Statements/Issues

- Current inspection and monitoring techniques for locks and gates do not effectively reveal imminent failure
- Corrosion detection and monitoring systems for steel components can be invasive and destructive to the steel components
- The limited process for predicting and quantifying consequences can adversely impact investment decisions
- There is a lack of awareness of materials and methods in which USACE is most heavily invested, which could help guide appropriate materials and construction research to improve efficiencies

Problem Statements/Issues

- There is a lack of coating and corrosion prevention that are environmentally and operationally acceptable (vinyl, composite, paint)
- There is a lack of advanced innovative repair methods (new construction methods and materials) akin to the REMR Program
- Develop standard protocols and evaluation metrics for testing and demonstration of promising technologies (a la CPAR) approaches.
- Need cost-effective, efficient, operational subsurface and sub aqueous inspection tools for bridges, locks, breakwaters, jetties, dams, etc. (FRM RARG)

Problem Statements

- Shock and vibrations associated with filling and emptying are destructive to valves
- Monitoring and detection of concrete degradation (changes over time and magnitude) is either too invasive and destructive or ineffective
- Design and implementation guidance for bearings (types, reliability) is inadequate
- What is needed to develop system performance indicators and enable evaluation of system response to project operations

Problem Statements/Issues

- Need rapid damage assessment capabilities (satellite to Smartphone)
- Need rapid simulation capabilities (engineering & social)
- Need methods and tools for project lifecycle or multiple project lifecycle performance assessment at local and system scales
- What affect does component life expectancy have on a system scale maintenance program

Problem Statements/Issues

- Inadequate knowledge of the physics and monitoring of internal erosion (seepage and piping mechanics, monitoring) limits risk assessment and management.
- There is insufficient guidance or lack of technology for repair and replacement of in-structure waterstops (FRM RARG)

Questions/Discussion