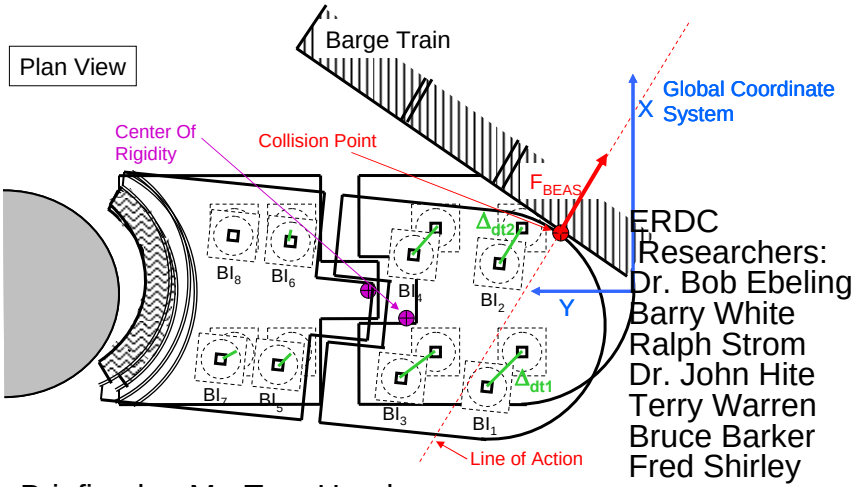
Navigation Safety Initiatives

Deformable Bullnose Energy Absorbing System (BEAS)



ERDC Researchers:
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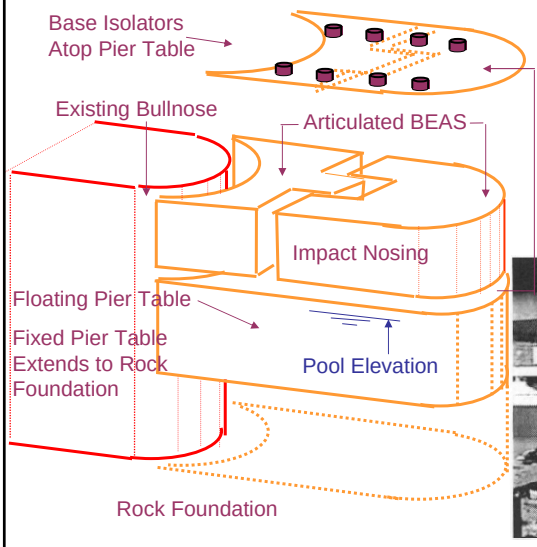
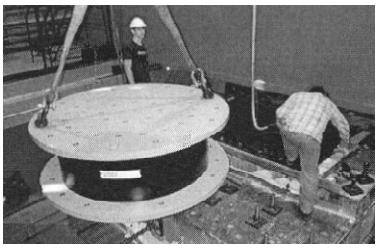
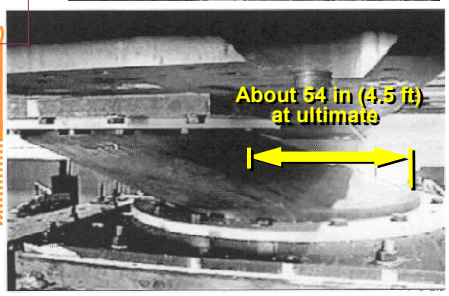
Ralph Strom
Dr. John Hite
Terry Warren
Bruce Barker
Fred Shirley

Briefing by: Mr. Tom Hood
7 February 2010

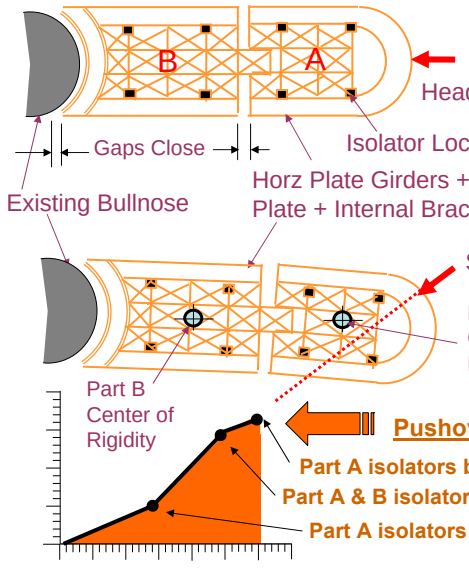
Impact Nosing Founded on Base Isolators



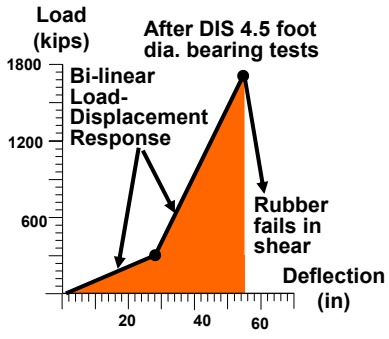




Plan View of Articulated Impact Nosing And Base Isolator Nonlinear Response



Single Isolator Load-Displacement Response to Failure



Pushover Analysis for Overall BEAS Response

Part A isolators begin to fail

Part A & B isolators reach load where barge lashings begin to fail

Part A isolators use up soft region

The Basic Physics of a Bullnose Energy Absorbing System (BEAS) Response

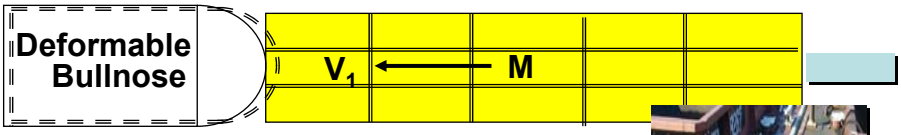
System Response Concept:

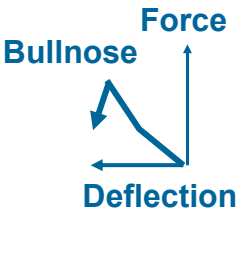
- The approach taken to solve this problem is to develop a new deformable bullnose.
- A rigid bullnose abruptly de-celerates the barge train during an impact.
- During an abrupt de-acceleration, the forces imparted to the lashings result in lashing failures and out of control "break-away" barges.
- The concept is to develop a deformable bullnose that allows the barge train to de-accelerate at a lower rate, thereby reducing the possibility for lashing failures .

Numerical Analysis of the BEAS to Barge Train Interactions

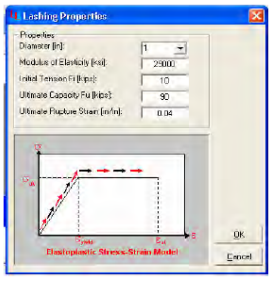
Plan View

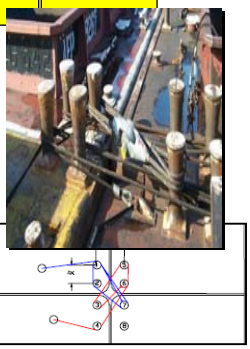
$\Sigma F = M a$





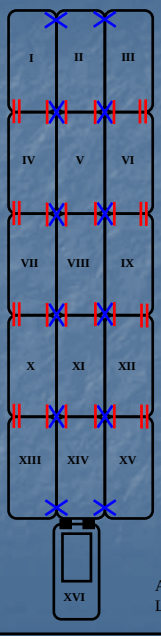
Wire rope





Model lashing layout

AEP Wire Rope Layout



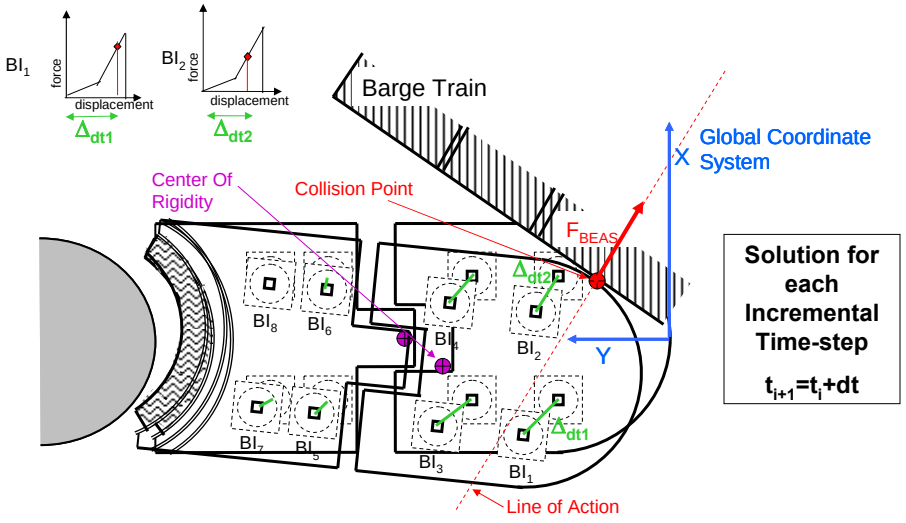
4 Part Fore – Aft Wire
3 Part Towing Wire
3 Part Backing Wire

All wires are 1 inch 6 x 36 IWRC

Industry wire rope layout will be used to investigate impact response with Deformable BEAS

AEP Model 1 Lashing Layout

Numerical Solution of Contact between Barge Train and Deformable BEAS



Solution for each Incremental Time-step

$t_{i+1}=t_i+dt$

Note: BEAS & Base Isolators shown with incremental base isolator deformations Δ_{dt1} for BI_1 and Δ_{dt2} for BI_2 in the figure at Time = t_1


© 2009 Europa Technologies
Image USDA Farm Service Agency
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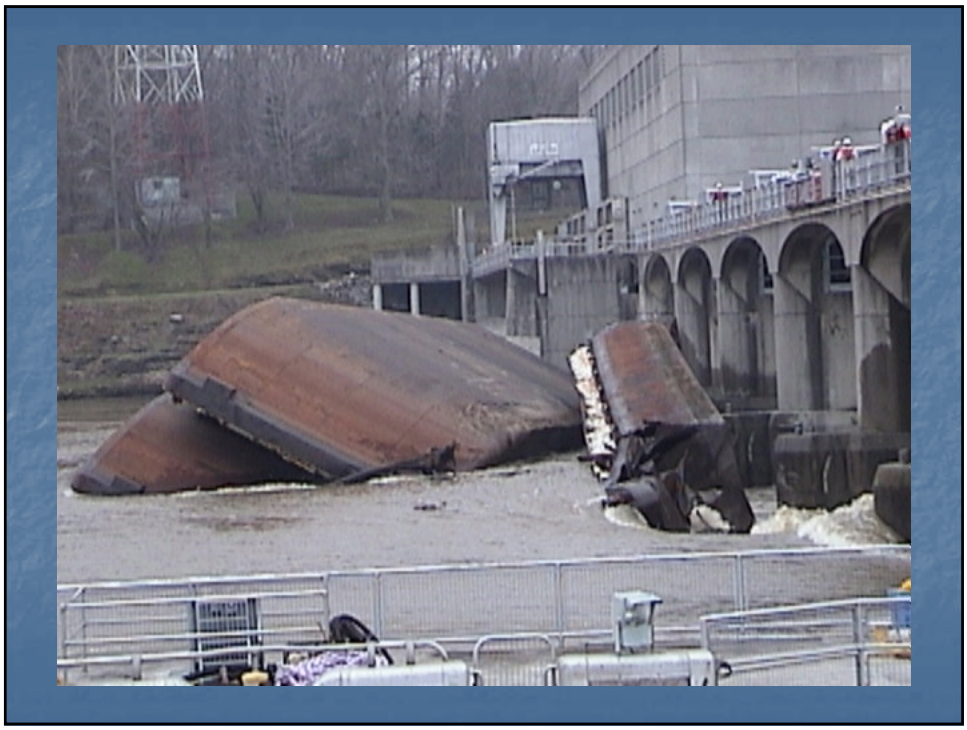


Need for R & D

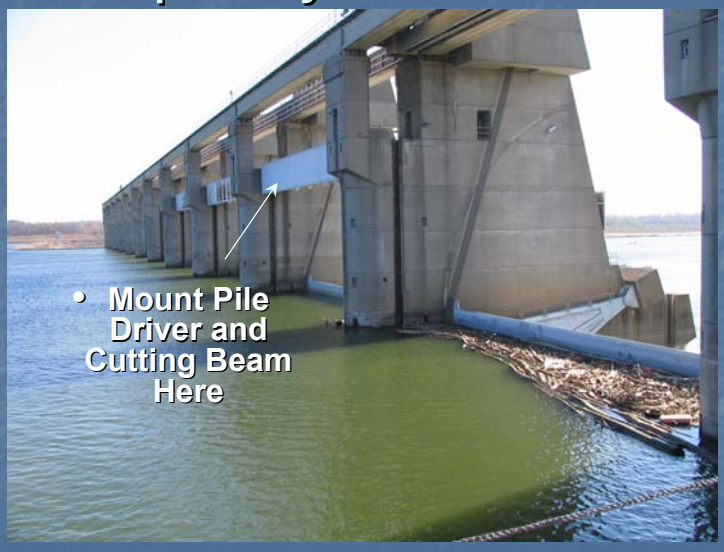
- **Methods to improve the Corps responsiveness to lessen the chances of loosing pool during future barge accidents involving barges hung on spillway piers.**

Belleville Barge Accident

Cutting Beam Discussion

- Desired cutting beam would need to be designed for use with some type of pile driver preferably a smaller vibratory type
- Cutting beam and pile driver could be mounted on the end of a crawler crane or excavator arm
- Cutting beam could be designed to fit on the bottom of the gate bay bulkheads

Spillway Bulkhead

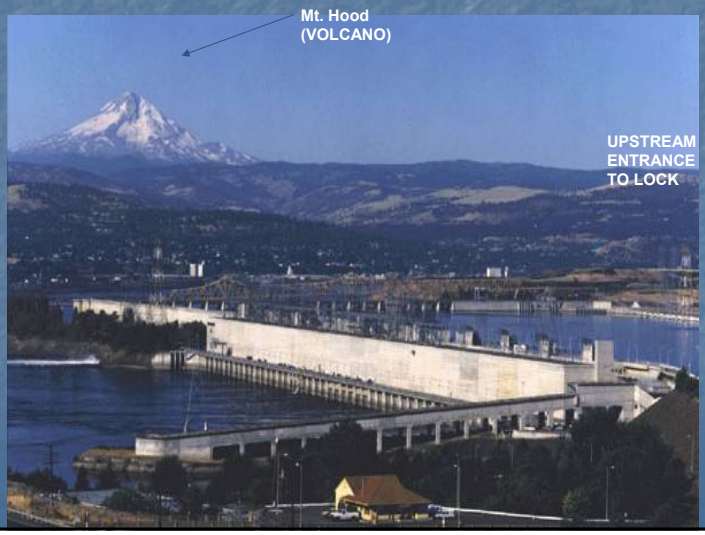


3 ft by 3 ft Electro Expulsion Panel Mounted on Starved Rock Lock Wall

Research Plan

- Meet with Supplier Jan 28 to discuss proposal
- Purchase 9 4-ft high by 7.5-ft wide panels
- Install at Upper Miter Gate Recess at Starved Rock Lock

The Dalles Lock and Dam, Columbia River at The Dalles, Oregon (Portland District)



Miter Gate Issues

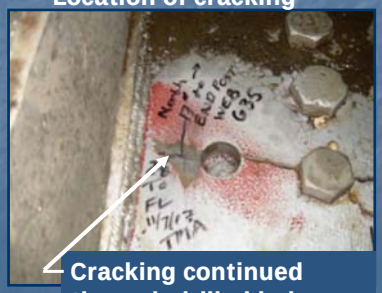
- Miter gate does not make miter or quoin contact. Load is being transferred through the pintle area
- The gate was not designed for this loading condition

Miter Block Erosion

Gate in Closed Position – No Miter Contact

Miter Gate Issues

Location of cracking



Cracking continued through drilled holes

Bolts hold gate to pintle

Crack running through web and into skin plate

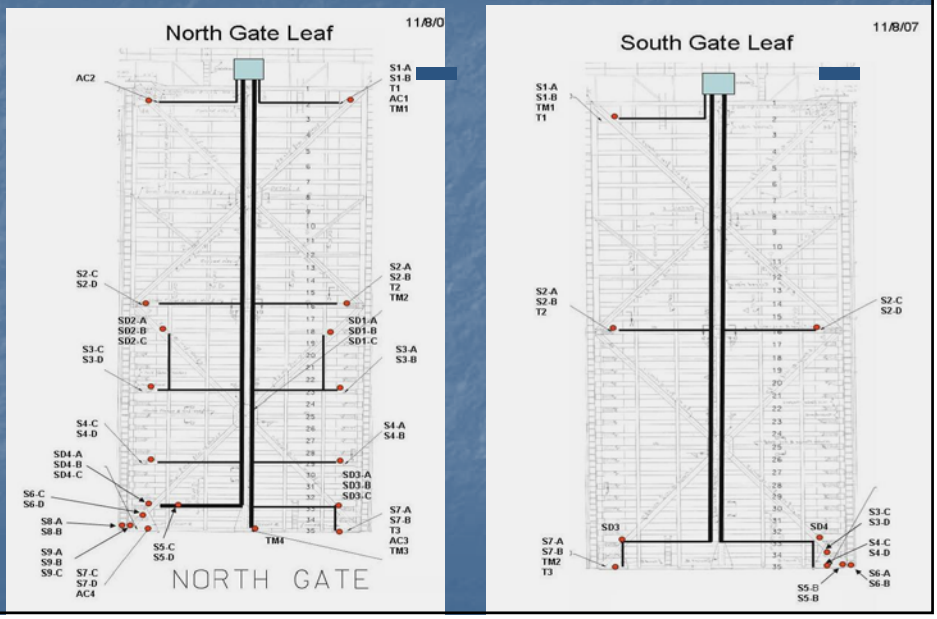
Miter Gate Issues

Pintle

Skin plate crack - upstream

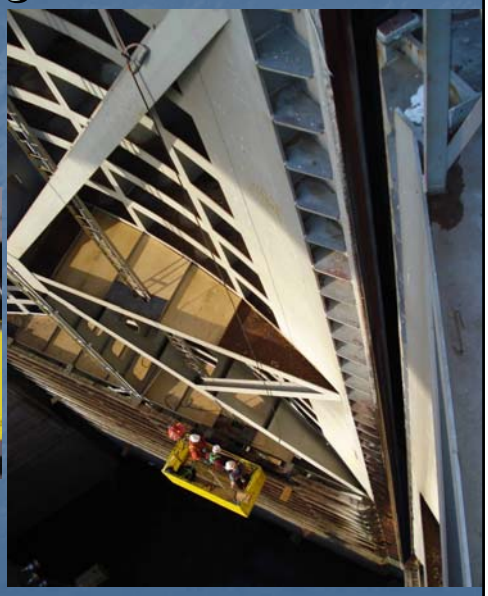
Upstream endpost cracking

Miter Gate Instrumentation Locations



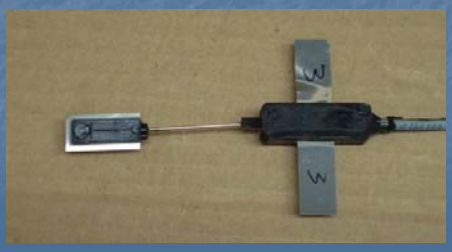
Miter Gate Gage Installation

Install done over a 7-day period with around-the-clock operation.



Strain Transducer Used

HiTech Products model HBWF-35-125-6-GP – used on miter gates



HiTech Products model HBWF-35-125-6-GP-SS similar to above, but with completion resistors removed from weldable area. Used on tainter gates

Strain Gage Installation

Cable Protection

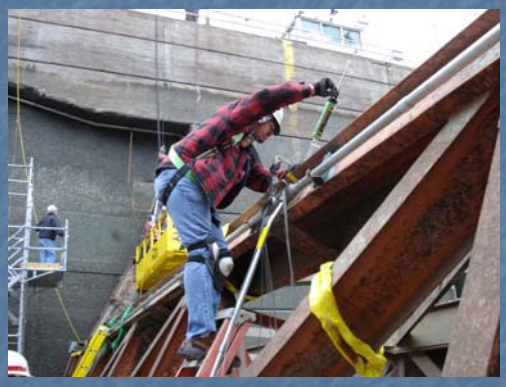



The Dalles L&D Upstream Gate


Upstream Tainter Gate Issues

- Gate damaged from numerous barge impacts
- Unequal load sharing (80% load on north side skews the gate).
- Diagonals continually cracking and requiring repair
- Stress data needed to assist design of new gate scheduled for replacement in 2013

Tainter Gate Instrumentation



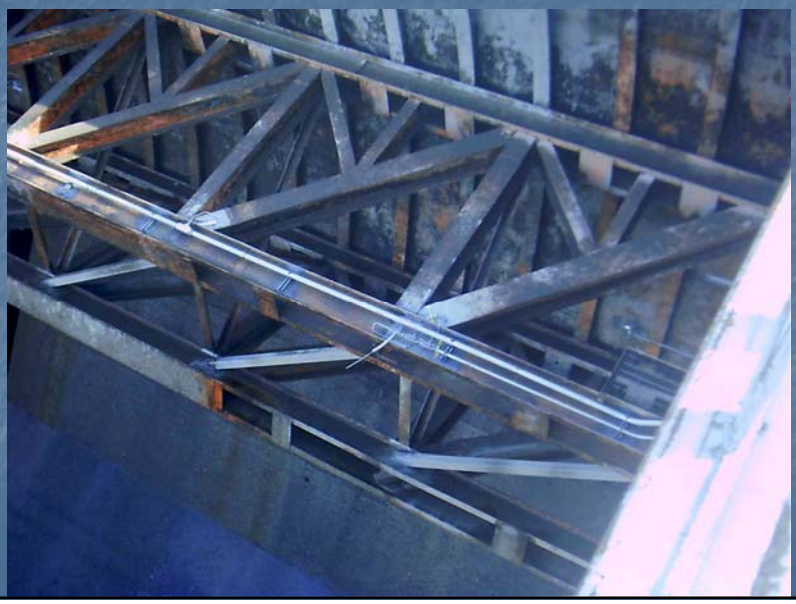
Gages Installed on Tainter Gates:

38 - Full-bridge strain gage sensors

4 – Tiltmeters

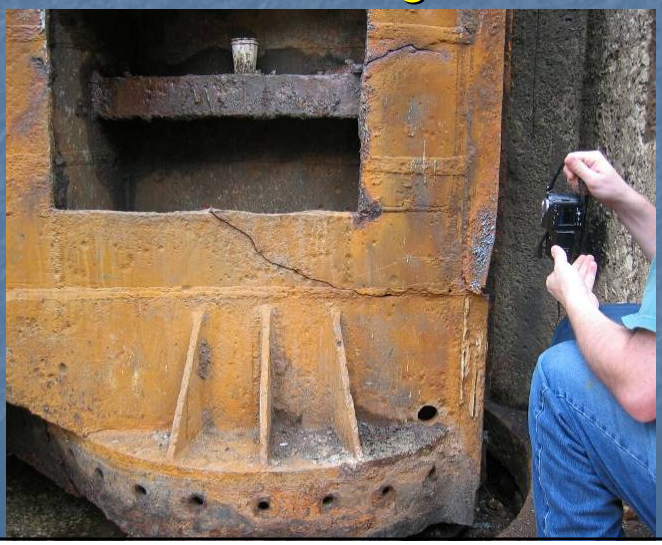
3 – Temp sensors

Tainter Gate Instrumentation



Damage to Reinforcement Flanging

Cracking Around the Pintle Casting



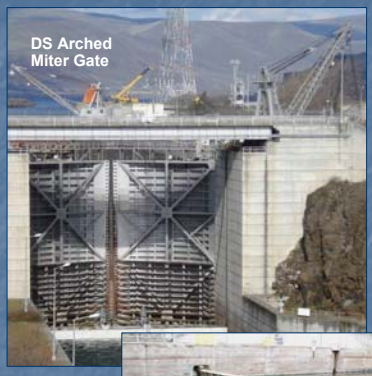
Miter Gate Issues

Cracking continued through drilled holes

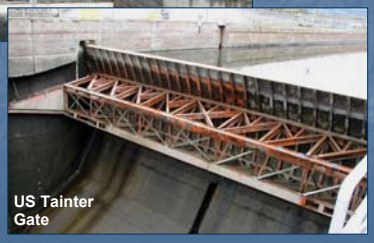
Bolts hold gate to pintle

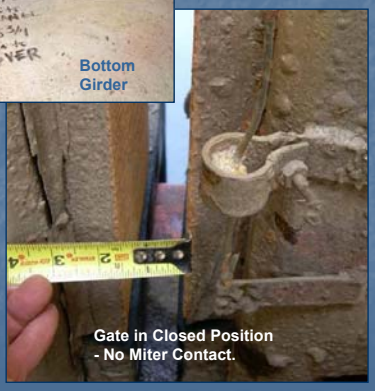
Crack running through web and into skin plate

The Dalles Lock and Dam, Columbia River, Oregon



Crack running through web and into skin plate





Structural Instrumentation

The purpose for the instrumentation:

- Monitor for deteriorating conditions
- Provide insight into the cause the damage
- Validate the FEM

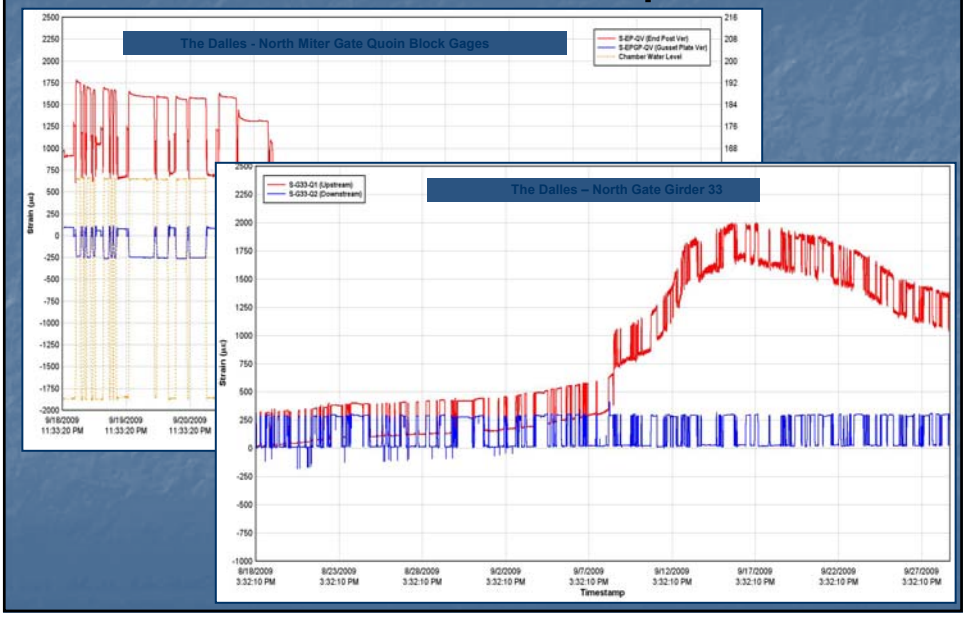
Gages Installed on Miter Gates:

- 97 Full-bridge strain gage sensors
- 10 Bi-axial tiltmeters
- 4 Tri-axial Accelerometers
- 10 Temperature sensors

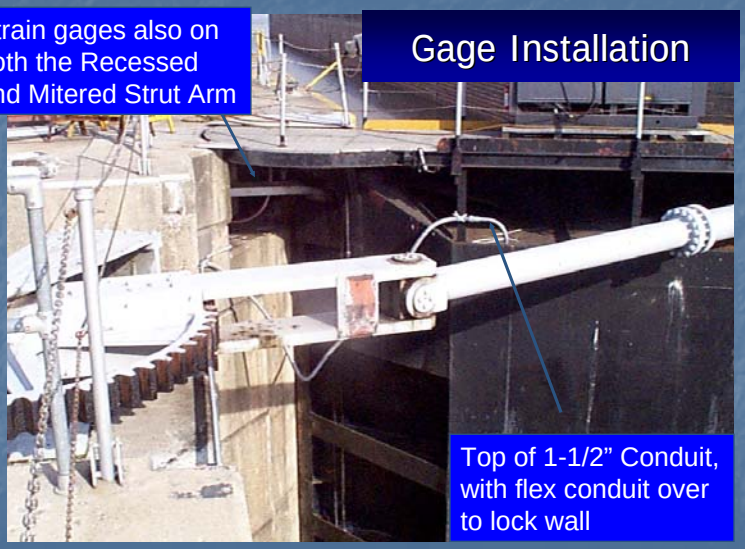
The Dalles Portal Showing Unusual Gate Behavior – Sept 2009

- On 29 Sept 2009 The Dalles nav lock was closed for operation.
- This decision was based largely on strain gage data.
- Inspection showed substantial damage to the lower girders and diagonals.
- Emergency repairs began on roughly 4 Oct.
- The lock re-opened for normal operation on 12 Oct.

Strain Data from Sept 2009

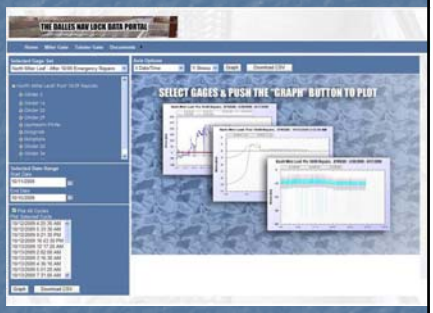


Greenup L&D Miter Gate



Current Research Under Nav Systems/Nav Safety Programs –SMART Gate

Structural Monitoring and Analysis in Real-Time (SMART) Gate Project Goals:



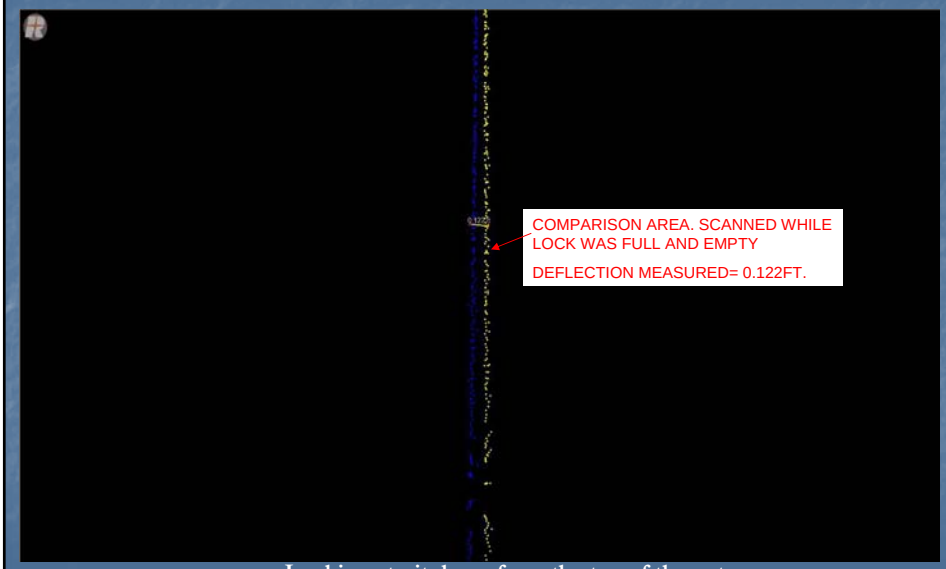
- Continue portal development using The Dalles as our test bed (FY10).
- Develop Best Practices methodology (FY10).
- Add automated alerts and reporting (FY10).
- Add engineering-based structural analysis (FY10 &11).
- Deploy a SMART Gate system at on a new miter gate (FY11).
- Develop ETL for structural monitoring of miter gates (FY11 &12).
- Transition technology to districts (ongoing).
- Long Range Goal – Merge FEM and Instrumentation for Virtual Inspection.

Acknowledgements

- SMART Gate PDT:
  Bruce Barker, Chris Lunderman, Chris Bogen, Guillermo Riveros, Tommy Carr
- SMART Gate Field Review Group:
  Travis Adams, NWP; Cameron Chasten, NAP; John Clarkson, LRH; Tom Hood, LRN; John Jaeger, NWK; Doug Kish, LRH; Bruce McCracken, NWD; Phil Sauser, MVP; Chris Westbrook, HQ02; Pete Rossbach, HQ02
- We are immeasurably grateful to Travis Adams and personnel at The Dalles L&D, and the Portland District for giving us the opportunity to serve.
- Jeff Lillycrop, Eddie Wiggins, and Jim Clausner with the ERDC Navigation R&D Programs; and Tom Hood, with Navigation Safety Initiative; for their continued support.

WILSON DAM LOWER GATE SCAN AREA
(1 MINUTE SCAN SHOWN AS COLORIZE POINT CLOUD)

WILSON DAM LOWER GATE COMPARISON AREA
(1 MINUTE SCAN)



Looking strait down from the top of the gate.

WILSON DAM LOWER LANDSIDE WALL SCAN AREA
(5 SECOND SCAN)