Movable Bridge Maintenance and Preservation

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Agenda

• Movable Bridge Overview
• Structural Preservation
  – Substructure
  – Superstructure
• Mechanical Preservation
• Electrical Preservation
• Other Concerns and where we are headed
Movable Bridge Overview

• Pound for pound, movable bridges are a DOT’s most expensive investment
  – More machine than structure
  – Millions of pounds of steel and concrete rotate, raise or pivot often in less than 90 seconds
  – More susceptible than most bridges to major impacts that can render a bridge inoperable
  – Requires unique expertise in the fields of structural, mechanical and electrical design and maintenance to properly care for the bridges
## Movable Bridge Overview

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<th>Vertical Lift</th>
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<td>2003 Deficient</td>
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<td>328</td>
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* Structurally deficient and not included in Functionally Obsolete
** Functionally obsolete
Deficient – sum of SD and FO
Movable Bridge Overview

• On the NBI, movable bridges represent
  – Less than 0.15% of the total number of bridges but nearly 1% over total area
  – About 0.35% of the SD bridges but nearly 2.8% over the total area of SD bridges
  – About 0.4% of the FO bridges but over 0.7% of the total area of FO bridges
  – Less than 0.4% of the deficient bridges but over 1.7% of the total area of deficient bridges
Movable Bridge Overview

• Florida leads the country in movable bridges with 145 movable bridges (2013)

• Variations within each major type complicate maintenance
  – Vertical lifts include span and tower drive, telescoping lifts, direct lifts
  – Bascules include trunnion style, rolling lift, Page type and retractile such as Rall type
  – Swing bridges include bob-tail and center pivot
STRUCTURAL PRESERVATION
Sub-structure Preservation

• Unchecked sub-structure deterioration undermines the bridge structure exposing pile tops
• Sheet pile and grouting is probably the only viable repair for this level of deterioration
Sub-structure Preservation

• Water infiltration is the greatest threat to sub-structure preservation
  – Freeze thaw on old concrete causes deterioration
  – Corrosive salt water causes rebar corrosion
  – Preventing infiltration of water through the use of epoxy injection and water expansive grouts can extend the life of the substructure
  – Use of marine type and high performance concretes for new structures can extend the life of concrete substructures
Sub-structure Preservation

• Maintaining sump pumps and keeping the pit clean will extend the life of the sub-structure

• Protecting concrete under bearings and seats ensures proper load transfers to substructure
Sub-structure Preservation

• Attention to the condition of anchor rods and bearings will ensure proper structural support

• Proper functioning of bearings prevents further concrete deterioration and cracking
Sub-structure Preservation

• Greatest threat to movable bridges is vessel impact
• It is often difficult to prevent, costly when it happens and can have a significant impact on area traffic
Sub-structure Preservation

- Steel piles and large diameter cased drilled shafts are effective long term solutions to pile deterioration
- Composite fender systems extend life and reduce maintenance costs
SUPERSTRUCTURE PRESERVATION
Superstructure Preservation

• Greatest challenge to preservation of bridge superstructure is road salt and debris
  – Typically use open decks to reduce structural loadings
  – In northern regions, where extensive road salt is used, salts and debris get carried on to the deck and get dropped on structural members
  – Approach structures are often concrete decks which may leak on to the machinery located below
Superstructure Preservation

• Open deck structures are light but allow supporting structure deterioration

• Gratings are susceptible to fatigue due to deterioration of bearing bars
  – Repairs are often ineffective
Deferred maintenance ultimately costs money
Superstructure Preservation

• Orthotropic decks can offer an effective means of preserving the superstructure
  – Can lighten the weight of the superstructure
  – Deck coatings may be susceptible to failure due to salt infiltration
Superstructure Preservation

- Concrete filled grid decks offer long term protection but increase dead load
  - Half filled concrete decks reduce overall dead load
  - Concrete filled grid decks are less susceptible to fatigue
Superstructure Preservation

• Bolting, rather than welding, grating to stringers makes deck replacement easier
  – Galvanized steel bars rest on the stringers to provide support
  – Bolting to stringers holds grating in place
Superstructure Preservation

• Movable bridge main members are usually fracture critical and corrosion of gusset and main members increases structural problems
• Regular deck washing can help preserve structural members
Superstructure Preservation

• FRP material for sidewalks provides a durable alternative to shallow concrete and timber decks

• Attachments are critical for long term serviceability
Superstructure Preservation

• Employee safety is paramount
  – If it is not safe to access, it won’t be maintained
  – Design platforms to be corrosion resistant and highly visible
  – Meet OSHA requirements
MECHANICAL PRESERVATION
Mechanical Preservation

• Proper bridge balance will extend the life of bridge machinery

• Strain gage testing is the most reliable means of determining balance
  – Typically slightly span heavy to ensure proper seating
  – Determination of the center of gravity is essential to ensuring that there are not unusual loadings on the machinery
Mechanical Preservation

• Adjust center, heel and end locks to ensure proper transfer of live loads and to avoid inducing live loads into mechanical system
• Adjust cables on vertical lift bridges to equally carry loads
• Adjust live load bearings and anchor columns to ensure proper load transfers
Mechanical Preservation

- Too much grease is as bad as too little grease
  - Dirt becomes embedded in old grease and can increase gear wear
  - Too little grease reduces gear life
  - Excess grease is a safety hazard for maintenance crews
Mechanical Preservation

- Clean gears during inspections to verify wear and metal flow which may indicate an unbalance condition on the bridge
Mechanical Preservation

• Keep cable clean to extend life
• Excessive scoring of sheaves might indicate a potential unbalance of the bridge or unequal loading of cables
Mechanical Preservation

• Proper machinery and motor brake adjustment is essential for safe operation

• Brake failure coupled with a bridge unbalance can lead to significant bridge damage
Mechanical Preservation

- Improper alignment of machinery can have major and costly impacts.
Mechanical Preservation

• Hydraulic drives require special attention
  – Damaged and worn seals can cause loss of fluids
  – Cylinders are exposed to elements and can deteriorate
  – Fluid can become contaminated and increase wear on vanes and other system components
ELECTRICAL PRESERVATION
Electrical Preservation

• Control systems should be tailored to the skills of the crews that are to maintain them
  – Advanced control systems such as PLC are great for bridge operators but may not be suited to an agency’s pool of maintainers
  – Listen to your maintainers and ensure that they are trained in the control systems used on your bridges
Electrical Preservation

• Well maintained older style control systems can work effectively
  – Availability of replacement parts is the principal limitation
  – Often do not meet current electrical codes
Electrical Preservation

• If it doesn’t look like it meets code, it probably is not reliable and should be replaced
• Weather, salt and vandalism pose the biggest problems to maintaining electrical systems
OTHER CONCERNS AND WHERE WE ARE HEADED
Design and Maintenance for Preservation

• Closed decks protect superstructures and should be designed for easy replacement
• Keep main structural members below the deck if possible
• Perform regular cleaning of super and substructures
• Composite material sidewalks improve walkability and reduce maintenance
• Ensure that maintenance platforms are durable and safe for use
Design and Maintenance for Preservation

• Keep the bridge in proper balance to reduce wear on gears
• Adjust bearings to ensure they are supporting loads
• More grease is not necessarily better – grease as appropriate, not for the sake of greasing
• Properly maintain electrical systems to code and regularly test to ensure proper operation
Design and Maintenance for Preservation

• Maintain fender and dolphin systems to protect bridge

• Ensure that operators are trained in the proper operation of the bridge – they can do more damage than any salt

• REGULARLY OPERATE THE BRIDGE – LIKE ANY MACHINE, IT BENEFITS FROM REGULAR USE AND WILL OPERATE BETTER IN THE LONG RUN
Building Preservation

• Many movable bridges are considered historic and warrant preservation
• Bridge houses are the most obvious historic element
• Handrails and other features can be historic as well
• An ongoing program of preservation of the architectural elements will reduce costs in the long run
• Movable bridges are a natural place for unwanted people to hang out
  – Often difficult to secure
  – Access can be achieved along the water or through the truss chords
  – Passive intruders set up house, active intruders strip out anything that can be salvaged
  – A function of frequency of operation, staffing in the bridge house and location
Alternate Preservation Methods

• Movable bridges were traditionally operated and maintained by “in-house” personnel experienced in the maintenance and operation of these bridges

• Moving towards asset management of movable bridges by third party providers
  – Requires quantifiable performance measures to preserve asset
  – If properly used, can improve operation of bridges
Reference Information

- *Movable Bridge Engineering* by Terry Koglin is an excellent handbook on the maintenance and operation of all movable bridge types
- AASHTO *Movable Bridge Inspection, Evaluation and Maintenance Manual*
- AASHTO *Movable Highway Bridge Design Specifications*
QUESTIONS