Stay Cable Replacement of the Luling Bridge

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Upper Anchorage
Stay Cables
Statement of Problem

- Rusting and water leakage in anchorage zones
- Cracking/splitting of cable cover pipes
- Signs of compromise in cables safety
- In 2002, LADOTD initiated a project for Structural Evaluation of the Stay Cables
Three Phases of Investigation

- **Phase I**: Assessing extent of problems and the overall integrity check
- **Phase II**: Hands-on inspection of the suspect locations and critical elements
- **Phase III**: Detailed design of repairs
Phase II- Inspection
Inspection of Deck Anchorage Boxes
Source of Problem
Cable Free Length Inspection
Cable Free Length Inspection

Hands-on inspection and Tap Testing
Cable Free Length Inspection

Thermography
Damages to Anchorage Zone

- Missing or broken seals
- Broken transition joints
- Open grout ports
- Corrosion of sockets and wires
Damages to Cable Free Length

- Damages to UV protection tape
- Grout voids & delamination
- Bulges and holes in the PE
- Longitudinal & transverse splits in PE
- PE joint separations
- Failure of previous repairs
- Exposure & degradation of grout filler
- Exposure & corrosion of steel wires
## Inspection findings
### Damage Severity Levels

<table>
<thead>
<tr>
<th>Severity Level</th>
<th>Status</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Satisfactory</td>
<td>Minor deterioration and anomalies noted</td>
</tr>
<tr>
<td>2</td>
<td>Poor</td>
<td>Deterioration of the protective elements and potential for degradation. Cables with this level of damages need to be routinely monitored and corrective action needs to be planned.</td>
</tr>
<tr>
<td>3</td>
<td>Critical</td>
<td>Deterioration or potential for deterioration of the main tension elements (steel wires) exists. Action (repair) is necessary. Cables with this level of damages shall be closely monitored until repairs are applied.</td>
</tr>
</tbody>
</table>
Severity Level 3, Exposed Grout and Steel Wires, Heavy Rust
Summary

- 40 out of 72 cables are rated critical
- All cables have at least damage Level 2
- Damage causes still present
- Increasing rate of deterioration is evident
- Timely corrective action is needed
Decision Making
Life Cycle Cost Analysis

- Define planning horizon
- Define repair strategies
- Estimate costs for strategies
- Calculate present values
- Select preferred strategy
Repair/Replacement Strategies

- Base Case
- Repair all
- Repair-Replace 1
- Repair-Replace 2
- Replace all
Cost Structure

- Initial Costs
- Distributed Annual Costs
- Periodic Repair Costs
- Vulnerability Costs
- Agency Costs
- Users’ Costs
Comparison among Cost of Various Strategies

Initial Cost

Present Value ($ Millions)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Initial Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>0.7</td>
</tr>
<tr>
<td>Repair all</td>
<td>6.4</td>
</tr>
<tr>
<td>Repair-Replace 1</td>
<td>10.1</td>
</tr>
<tr>
<td>Repair-Replace 2</td>
<td>14.0</td>
</tr>
<tr>
<td>Replace all</td>
<td>19.0</td>
</tr>
</tbody>
</table>
Comparison among Cost of Various Strategies

Initi. + dis. + Per. + Vuln. Costs

Present Value ($ Millions)

- Base Case: 35.9
- Repair all: 20.2
- Repair-Replace 1: 19.8
- Repair-Replace 2: 20.5
- Replace all: 19.9
Phase III

- Additional Inspection
- Cable Replacement Design
Cable Replacement Design Team

Client: Louisiana Department of Transportation and Development (LADOTD), Paul Fossier, Project Manager,

Prime Consultant: CTLGroup
Project Manager: Armin Mehrabi, Bridge Engineering Solutions
Cable replacement design: International Bridge Technologies, Inc.
Deck repair design: TranSystems
MOT, Survey & Plans: ABMB Engineers, Inc.
Cable Replacement Design

Objectives:

- Develop a cost effective design that requires minimal engineering by contractors.
- Minimize impact on traffic and Maintenance of Traffic (MOT).
- Analyze for live load, wind force, and construction load effects.
Assess current conditions

- Existing Cable Forces
- Geometry Survey
- Superstructure Inspection
Replacement Cable Design

Cable systems considered

- Parallel strand system
- Parallel wire system
Replacement cable design

- Parallel strand, preferred system
- Availability in the US
- Used in most new bridge constructions
- Ease of inspection and replacement
- Corrosion protection system

- No major failures documented in bridges using this system
Replacement cable design

Parallel strand, preferred system

- Larger anchorages
  - requiring modifications
  - Increase wind load
  - Change aerodynamic characteristics

Installation method

Equivalent stiffness (24, 48, 61, 71 strand)

Additional 24 reference strand
Maintenance of Traffic
Temporary cable design

Need for Temporary cables

- Uncertainty in cable condition
- Large cable group spacing
- Need to maintain traffic w/o load limits
Temporary cable design
Construction Sequence

Highlights:
- Using Temporary Cables
- Using “Highline” or “Cableway”
- Limiting operation to one side
- Minimizing construction space needs on deck and impact on traffic
- Concentrating operation at deck level
  - Use of saddle as top support
  - Lower ends as live ends
Construction Sequence
Construction Sequence
Construction Sequence
Modeling & Structural Analysis

- CAD model to determine geometry conflicts
- Finite Element Model for structural analysis
CAD Model
Modeling and Structural Analysis
Finite Element Analysis

- Analyze each stage of construction
- Generate member action envelopes for all load combinations
- Provide geometry control variables
- Determine stressing sequences
- Analyze Live load, wind load and construction load effects
Design for Peripherals

- Anti-vandalism and security
- Cable vibration suppression measures
- Anchorage drainage design
Cable Vibration Suppression Measures
Cable Vibration Suppression Measures
Anchorage Box Drainage

- Existing Cable Anchorage
- Existing Access Hatch
- New Drain Pipe Assembly
- Approximate Location of New 1 3/8" Dia. Drainage Hole
Other Work

- Deck repairs, weld cracks & Joint
- Cable instrumentation for wire break
- Cleaning & sealing of the superstructure
- Access hatch retrofit
- Fairing plate repair
Summary

- Inspection performed 2004-2006
- Cable replacement design 2007-8
- Final Plans submitted Dec. 2008
- Project bid February 25, 2009
- Construction begins Summer/Fall 2009
Questions?