Stay Cable Replacement for the Luling Bridge

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Stay Cables
Deck and Cross Girder
Lower Anchorage
Upper Anchorage
Statement of Problem

- Rusting and water leakage in anchorages
- 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
Source of Problem

Diagram:
- Neoprene washer
- Receptacle steel box
- Steel collar flange
- Stay cable
- 3" split washer
- Split shims and clamp plate
- Cross girder box

Photos:
- Close-up of the problem area
- Close-up of the components in action
Cable Free Length Inspection
Cable Free Length Inspection

Hands-on inspection

Tap Testing

Thermography
# 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, Damage Examples
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 was 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

Each cost element includes:
- Agency Costs
- Users’ Costs
Comparison among Cost of Various Strategies

Initial Cost

Present Value ($ Millions)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Present Value</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

Present Value ($ Millions)

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>35.9</td>
</tr>
<tr>
<td>Repair all</td>
<td>20.2</td>
</tr>
<tr>
<td>Repair-Replace 1</td>
<td>19.8</td>
</tr>
<tr>
<td>Repair-Replace 2</td>
<td>20.5</td>
</tr>
<tr>
<td>Replace all</td>
<td>19.9</td>
</tr>
</tbody>
</table>

Initi. + dis. + Per. + Vuln. Costs
Phase III

Cable Replacement Design
Cable Replacement Design Team

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

Project Manager: Armin Mehrabi, Bridge Engineering Solutions
Prime Consultant: CTLGroup
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.
- Analyze for live load, wind force, and construction load effects.
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
- Strand-by-strand installation

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

Parallel strand, preferred system

- Larger anchorages
  - Require modifications of existing structure
  - Increase wind load
  - Change aerodynamic characteristics

- New Cables; 24, 45, 57, 68 strand
- Additional 24 reference strand
Maintenance of Traffic

PEAK TRAFFIC OPERATION

NON-PEAK TRAFFIC OPERATION
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
Temporary Cables
Construction Sequence
Construction Sequence
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Construction Sequence
Construction Sequence
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

Cable vibration suppression measures
Cable Vibration Suppression Measures
Cable Vibration Suppression Measures
Summary

- Inspection performed 2004-2006
- Cable replacement design 2007-8
- Construction project bid Feb. 25, 2009
- Construction began Fall 2009
Questions?

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