Truss Monitoring Program for the Huey P. Long Bridge Widening Project

Louisiana Transportation Conference
February 10, 2009

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Principal and Group Manager
www.CTLGroup.com
OUTLINE

- TRUSS MONITORING SPECIFICATION
  - Eyebar Force Measurements
  - Static Strain Gage System
  - Live Load Strain Gage System
  - Load Test
  - Baseline Measurements
  - Construction Monitoring

- WEB SITE POSTING OF DATA

- ACKNOWLEDGEMENTS
TRUSS MONITORING PROGRAM

TRUSS MONITORING SPECIFICATION (S-107)

- Eyebar Force Measurements
- Static Strain Gage System
- Tilt Meters on Piers
- Live Load Strain Gage System
- Load Test
- Baseline Measurements
- Construction Monitoring
TRUSS MONITORING PROGRAM

LOGISTICS

- Safety 1st
- Limited Working Hours
- Three Month Time Period
TRUSS MONITORING PROGRAM

• EYEBAR FORCE MEASUREMENTS (96 total)
TRUSS MONITORING PROGRAM

EYEBAR FORCE MEASUREMENTS
- Data Collected in Time Domain
- Post-Processed in Frequency Domain
- Force Based on Measured Frequency (taught string theory)

Comparison of Forces, kips

<table>
<thead>
<tr>
<th></th>
<th>UA1-UA0</th>
<th>UA1'-UA0'</th>
<th>UC2-UC3</th>
<th>UC2'-UC3'</th>
<th>LS0-US0</th>
<th>LS0'-US0'</th>
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<td>UC2'-UC3'</td>
<td>LS0-US0</td>
<td>LS0'-US0'</td>
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<tr>
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<td>PREDICTED</td>
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<td>UC2-UC3</td>
<td>LS0-US0</td>
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<td></td>
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<tr>
<td>DL + Hwy LL + I</td>
<td>471</td>
<td>411</td>
<td>353</td>
<td></td>
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</tbody>
</table>
TRUSS MONITORING PROGRAM

- **STATIC MONITORING SYSTEM**
  - 433 Members (777 Vibrating Wire Strain Gages)
  - 5 Piers (10 Vibrating Wire Tilt Meters)
  - Wind Speed/Direction

- **DYNAMIC (LIVE LOAD) MONITORING SYSTEM**
  - 31 Members (50 Electrical Resistance Strain Gages)
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- STATIC STRAIN GAGES
  - Floor Beam Brackets (264 gages)
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- STATIC STRAIN GAGES
  - Vertical Hangers (144 gages)
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- STATIC STRAIN GAGES
  - Top and Bottom Chords (168 gages)
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- STATIC STRAIN GAGES
  - Top and Bottom Laterals (108 gages)
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- STATIC STRAIN GAGES
  - Portal and Sway Frame Members (93 gages)
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TILT METERS AND WEATHER STATION
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- LIVE LOAD STRAIN GAGES
  - Always Match a Static Gage (50 gages)
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STATIC DATA COLLECTION SYSTEM

- Hardwired Static Strain Gages
- Wireless Strain Gage Multiplexer
- Wireless Static System Datalogger
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- DYNAMIC DATA COLLECTION SYSTEM

- Live Load Strain Gages
- Hardwired Live Load Dynamic System (wireless to MTI)
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DEBUGGING SYSTEM
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LOAD TEST

- Calibrate Truss Monitoring System with HNTB Model
  - HNTB proprietary structural analysis using direct stiffness method
- Locomotives of Known Weight
  - Hoped to have minimum of two
- Moving Loads Across Bridge
  - Series and parallel
- Stationary Loads
  - Series and parallel
- Vibration Measurements of Eyebars
LOAD TEST

- Data collection on command
- Majority of tests had only one locomotive (415k)
- Higher loads would be better
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COMPLETED DATA COLLECTION SYSTEM

- Static Strain Gage
- Live Load Strain Gage
- Wireless Static Strain Gage Mux (wireless to Data Logger)
- Hardwired Live Load Dynamic System (wireless to MTI Office)
- Wireless Static System Data Loggers (wireless to MTI Office)
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DATA PROCESSING

- Static System Continuous
  - Scan every 10 minutes
  - Store every hour
- Dynamic System On-Command
  - Polled remotely
- Axial Stresses
- Bending Stresses
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BASELINE MEASUREMENTS

- Initial Readings
- Independent of Construction Activity
- Stability of Measurements
- Dummy Gages
- Measure Normal Traffic Conditions
- Measure Temperature Effects
- Hurricane Gustav
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MEASUREMENT FLUCTUATION (100 ue = 3 ksi)

![Graph showing measurement fluctuation over time.](image)
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- DUMMY GAGES (100 ue = 3 ksi)
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HURRICANE GUSTAV (wind)

- Fay 8/23
- Gustav 9/1
- Ike 9/13
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HURRICANE GUSTAV (strain)
CONSTRUCTION MONITORING

- Establish Limits for Predicted Response for Staged Construction
- Compare Measured with Predicted Response
  - Daily Comparisons
  - Each Stage of Construction
- Account for Baseline Fluctuations
  - Traffic Loads
  - Locomotive Loads
  - Temperature Effects
- Automated Flagging of Limits
TRUSS MONITORING PROGRAM

Web Page Format

EXISTING STRUCTURE

HUEY P. LONG BRIDGE WIDENING - MAIN SPAN SUPERSTRUCTURE

LOUISIANA DOTD State Project No. 006-01-0018

TRUSS MONITORING SYSTEM DAILY REPORT

CONSTRUCTION PHASE: Step 2

Monitoring Results - Real Time

<table>
<thead>
<tr>
<th>Member</th>
<th>Measured Baseline</th>
<th>Predicted EL</th>
<th>Baseline + EL</th>
<th>Measured Const. Related Stress</th>
<th>Within the Range?</th>
<th>Exist DL Stress</th>
<th>Total Stress</th>
<th>Allowable Stress</th>
<th>Percent of Capacity</th>
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<tbody>
<tr>
<td></td>
<td>min</td>
<td>max</td>
<td>min</td>
<td>max</td>
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Cantilever Truss, Upstream

Floor Beam Brackets

- LA14 U. FEN
- LA13 U. FEN
- LA12 U. FEN
- LA11 U. FEN
- LA10 U. FEN

Transferring data from localhost...
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SYSTEM ACCESS
- Web Site Posting of Data
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MEASURED BASELINE FLUCTUATION
  - Over a selected time period

---

<table>
<thead>
<tr>
<th>Member</th>
<th>Measured Baseline Fluctuation (stresses)</th>
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**Floor Beam Brackets**

| LA14 U FBN | -1.21 | 2.66 | 0.33 | -1.54 | 2.98 | 0.52 | YES | 4.86 | 5.18 | 0.00 | 24.75 | 20.92% | OK |
| LA14 U FBS | -2.38 | 2.60 | 0.33 | -2.79 | 2.93 | 0.18 | YES | 4.66 | 4.84 | 0.00 | 24.75 | 19.67% | OK |
| LA15 U FBN | -1.26 | 3.67 | 0.33 | -1.60 | 3.90 | 0.75 | YES | 8.56 | 9.31 | 0.00 | 24.75 | 37.63% | OK |
| LA15 U FBS | -1.42 | 2.78 | 0.33 | -1.75 | 3.11 | 0.18 | YES | 8.56 | 8.71 | 0.00 | 24.75 | 36.19% | OK |
| LA12 U FBN | -0.71 | 4.41 | 0.33 | -1.04 | 4.74 | 1.33 | YES | 9.56 | 10.38 | 0.00 | 24.75 | 41.92% | OK |
| LA12 U FBS | -0.99 | 3.84 | 0.33 | -1.32 | 4.18 | 1.32 | YES | 9.56 | 9.87 | 0.00 | 24.75 | 38.93% | OK |

**Cantilever Truss, Upstream**

- Transferring data from localhost...
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MEASURED BASELINE FLUCTUATION

CHART 31
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PREDICTED ERECTION LOAD

- From HNTB model based on staged construction
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- BASELINE + PREDICTED ERECTION LOAD
  - Fixed values based on baseline fluctuation and stage of construction
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ACTUAL REAL TIME MEASUREMENTS
- Values updated every 10 minutes

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<td>2.66</td>
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</tr>
</tbody>
</table>

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TRUSS MONITORING PROGRAM

TOTAL STRESS IN MEMBER
- Measured stress + HNTB value for dead load

<table>
<thead>
<tr>
<th>Member</th>
<th>Measured Baseline Fluctuation (stress)</th>
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Transfering data from localhost...
TRUSS MONITORING PROGRAM

PERCENT OF CAPACITY
- Measured stress + dead load / allowable

<table>
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Cantilever Truss, Upstream

*Transferring data from localhost...*
TRUSS MONITORING PROGRAM

WEB-BASED DATA REVIEW
- Plotting and tabulation
ACKNOWLEDGEMENTS

- MTI JOINT VENTURE
  - Support of Paper/Presentation
- HNTB
  - Bridge Renditions