John James Audubon Bridge

Introduction
The Project
Why build the bridge?

• The bridge--proposed to be the longest cable-stayed bridge in America--will replace an existing ferry between the communities of New Roads and St. Francisville, Louisiana.
• The bridge will also serve as the only bridge structure on the Mississippi River between Natchez, Mississippi and Baton Rouge, Louisiana (approximately 90 river miles).
• The project is part of the Zachary Taylor Parkway, a scenic highway across Louisiana from Mississippi to Texas.
• Economic development for the area.

Data provided by Louisiana’s TIMED Program
## Overall Project Facts

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheduled Time to Complete</td>
<td>47 Months (February 2010)</td>
</tr>
<tr>
<td>Estimated Number of Man-Hours</td>
<td>793,000 MH</td>
</tr>
<tr>
<td>Number of Bridges</td>
<td>8</td>
</tr>
<tr>
<td>Concrete</td>
<td>99,000 CY</td>
</tr>
<tr>
<td>Reinforcing Steel</td>
<td>27,900,000 LBS</td>
</tr>
<tr>
<td>Structural Steel</td>
<td>14,500,000 LBS</td>
</tr>
<tr>
<td>Stay Cables</td>
<td>1,834,000 LBS</td>
</tr>
<tr>
<td>Asphalt</td>
<td>95,000 TON</td>
</tr>
</tbody>
</table>
Design/Bid/Build

Owner

Design Team

CEI or Construction Manager

Construction Contractor
The Joint Venture

The $348 million dollar project is being constructed by Audubon Bridge Constructors, a joint venture consisting of:

- Flatiron Constructors (Longmont, CO)
- Granite Construction Company (Watsonville, CA)
- Parsons Transportation Group, Inc. (Washington, DC)
Audubon Bridge Constructors

- Flatiron Constructors, Inc. (54%)
- Granite Construction Company (25%)
- Parsons Transportation Group, Inc. (21%)
Louisiana Department of Transportation & Development

- LA DOTD is the owner of this bridge and are managing the construction with the Louisiana TIMED Program.
Louisiana TIMED Managers (LTM)

- Louisiana TIMED Managers (LTM) serve as an extension of the Louisiana Department of Transportation & Development (LA DOTD).
John James Audubon Bridge

Roadways
Roadways: Clearing & Grubbing

12/08/2006
Move-in Equipment
Roadways

2 LANES @ 11' = 22'

LEGEND:

1. 8" SUPERPAVE ASPHALTIC CONCRETE (LEVEL 2)
   (2" WEARING COURSE)
   (3" BINDER COURSE)
   (3" BASE COURSE)

2. 4" SUPERPAVE ASPHALTIC CONCRETE (LEVEL 1)
   (2" WEARING COURSE)
   (2" BINDER COURSE)

3. CLASS II BASE COURSE (4" THICK)

4. CLASS II BASE COURSE (8" THICK)

5. OMIT

6. 4" THICK NON-PLASTIC EMBANKMENT

7. 8" CLASS II BASE COURSE (SOIL CEMENT)

8. GEOTEXTILE FABRIC
John James Audubon Bridge

Approach Structures
The Bridges

Approach Bridges

Bridge 1
Bridge 2
Bridge 3
Bridge 4
Bridge 5
Bridge 6
Bridge 7
Bridge 8
Approach Roadway Bridges

• 2 Lane and 4 Lane Configurations – Future Widening of Approach Roadway and Bridges
• LRFD Design Method
• Conventional Bridge Layouts and Construction Details- Use of Standard LA DOTD Details Such as Expansion Joints, Railing, Approach Slabs, etc.
Sample Bridge General Plan
Typical Section – Minor Bridges
Typical Sections
Approach Bridges
Steel Plate Girders Span the Levee
Approach Structures

• West Approaches
  – 2044’-6” long with 15 spans
  – Low Level Approach
    • Supported by PPC driven piles (six bents)
    • AASHTO Type III girders
  – High Level Approach
    • Supported by two 90” dia drilled shafts (nine piers)
    • Spans 3W to 6W utilize steel plate girders
    • Spans 7W to 10W utilize Bulb Tee girders
Approach Structures

• East Approaches
  – 6780’ long with 80 spans
  – Low Level Approach
    • Supported by PPC driven piles
    • 68 Spans with AASHTO Type III girders
  – High Level Approach
    • Supported by two 90” dia drilled shafts (twelve piers)
    • Bulb Tee girders for all spans
Deliver Piles by Truck
Drive Piles with Diesel Impact Hammer
Static Load Tests
Construct Pile Cap
Form for Pile Cap
More to come...
John James Audubon Bridge

Main Span
Cable-Stayed Bridge
General Arrangement

- 1583 ft main span
- 1463 ft navigational clearance provided
Towers:

- 500’ high
- 136 cable stays
- Two crossbeams
- Tower top is Elev. 520
- Deck is Elev. 130
Key Design Features

- Light superstructure supported by 136 stay cables
- Minimum loads on foundations
- Durability
  - Beneficial deck compression from stay cables and deck post-tensioning
  - 2 “ LTM overlay
  - 8000psi HPC precast deck panels
  - 50ksi weathering steel protected by deck
Main Span
Dead Load Analysis

• Dead load analysis is non-linear
  – Non-linear cable elements
  – Non-linear beam elements
  – Non-linear soil springs

• Structure is “tuned” for dead loads
  – Towers built tall to compensate for shortening
  – Deck built long to compensate for shortening
  – Cables installed short to compensate for stretch
Untuned Structure
Tuned Structure
Stage-by-Stage Analysis

• Structure built one segment at a time
• Precisely captures locked-in effects
• Models time-dependent effects during construction
• Required for tracking bridge geometry during construction
• Performed prior to bridge construction
Wind Loads

• AASHTO static wind load pressures not appropriate for long-span structures

• Three components to wind loads
  – Mean static
  – Background
  – Dynamic (Buffeting)
  – Dynamic component obtained from buffeting analysis provided by wind specialists
Sectional Model Tests
Sectional Model in Wind Tunnel
Aeroelastic Model in Wind Tunnel
Aeroelastic Model Details
Construction Stage Modeling
Construction Stage Modeling
Buffeting

- Dynamic response of structure from uneven loading due to turbulence in natural wind
- Buffeting induces vibration in the bridge’s natural modes of vibration
- The resulting forces which included dynamic inertial forces can exceed those calculated using simple static wind pressures
Buffeting Analysis

• Determine peak resonant response for each mode of vibration
• Input includes
  – Aerodynamic force coefficients
  – Structure dynamic properties (i.e. stiffness, mass, natural modes of vibration)
  – Structure damping
  – Wind turbulence properties
Buffeting Analysis

- Alternative to aeroelastic testing
- Obtain results faster
- Verify by measured response at limited positions during aeroelastic testing
- Requires modal superposition to determine peak response
Buffeting Demands

Input: Modes

RWDI Output: Scaling Factors

Result: Demands

→ 0.51 →

→ 0.27 →
# Buffeting Demands

<table>
<thead>
<tr>
<th>Mode</th>
<th>Force Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,100</td>
</tr>
<tr>
<td>2</td>
<td>200</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>650</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>n</td>
<td>21</td>
</tr>
<tr>
<td>$\sqrt{m_1^2 + m_2^2 + \ldots + m_n^2}$</td>
<td>1,350 (RMS Total)</td>
</tr>
</tbody>
</table>
Wind Load Combinations

<table>
<thead>
<tr>
<th>Case</th>
<th>Transverse Wind</th>
<th>Longitudinal Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100%</td>
<td>50%</td>
</tr>
<tr>
<td>2</td>
<td>50%</td>
<td>100%</td>
</tr>
<tr>
<td>3</td>
<td>70%</td>
<td>70%</td>
</tr>
</tbody>
</table>

Wind Load = Static + Background + Buffeting
Live Load Analysis

• HL-93 Live Load per AASHTO LRFD:
  – Truck Load (HS-20, 72 kips)
  – Tandem Load (50 kips)
  – Lane Load (640 plf)
• Four design lanes
• Demands obtained through influence surface loading
Live Load Analysis

Tower Foundation, $M_{\text{long}}$
Live Load Analysis

Edge Girder, $M_{\text{long}}$
Cable Loss Analysis

- Extreme limit state
- Cable loss in accordance with PTI Recommendations
- $1.1DC + 1.35\text{ DW} + 0.75\text{ LLI} + 1.1\text{Cable Loss}$
Cable Loss Design Philosophy

• Structural Elements Design to prevent structural instability
  – Prevention of progressive collapse
  – Member yielding and load redistribution permitted
  – Fully plastic behavior permitted
  – Brittle failure mechanisms prohibited
Cable Replacement

- Strength limit state
- In accordance with PTI Recommendations
- 1.2DC+1.4 DW+1.5LLI+Cable Exchange
- Adjust traffic pattern to control live load
- Limit areas where cable replacement governs
Non-Linear Behavior

- Flexible suspended structure (geometric)
- Cable stiffness due to sag
- Material properties at strength and extreme limit states
- Soil properties
Geometric Non-Linearities

- Non-linear beam elements
- 3-D beam elements with stability functions to capture P-delta effects
- Stability functions to account for stiffening and softening of structure under axial load
Non-Linear Performance

• Most significant non-linear performance is under dead load analysis
• Non-linear behavior due to superimposed loads are typically small
Non-Linear Analysis

• Geometric
  – Dead load analysis
  – Live load analysis for verification only

• Geometric and Material
  – Wind load analysis for critical cases
  – Construction stage analysis for critical cases
  – Cable loss analysis
Deck/Tower Articulation

- **Longitudinal Fixity**
  - Pier 1W & 2W – Fixed Bearing
  - Pier 1E – Lockup Device
  - Pier 2E – Sliding Bearing

- **Advantages**
  - Maintain flexibility for temperature movements
  - Spread longitudinal shear from wind to both towers
Lock Up Devices

Diagram:

- PISTON ROD
- PISTON HEAD
- ORIFICES
- END CLEVIS, 2 PLACES
- CAP AND SEAL
- CYLINDER
- FLUID
- CAP AND SEAL

Graph:

- Force [kN]
  - 16000
  - 50

- Velocity [mm/s]
  - Free movement
  - Prevented movement
  - 0.05
  - 2
Tower Foundations 1W & 1E

- 160’ x 64’ x 15’ Cap
- 7 by 3 pile group – 1 test pile
- 8’-0” diameter shafts
Tower Shafts

• 96” dia permanent casing
• 90” dia drilled shaft
• Pile tip Elev. -175 to -180
• Tip grouting
Tower Cross Section

- Box sections for simple jump forming
- Cable anchorage on inside tower wall
Tower Cable Anchorages

- Steel anchorage trays for upper stays
- Concrete corbels for lower steep cables
- Crossbeams connected clear of anchorage zone
Tower Form System
Composite Deck Cross-Section

- Economy, simplicity and constructability
- Durability
- Accessibility
- Low maintenance
Deck Anchorage
Stay System

- 7-Wire parallel strand
- Monostrand Jacking
- State-of-the-Art Corrosion Protection
  - Galvanizing
  - Grease
  - Strand PE
  - Coextruded HDPE Pipe
- Vibration suppression
Counterweight
Bridge Construction
Bridge Construction
Bridge Construction
Bridge Construction
Foundation Construction

Installation of Drilled Shafts
Drilled Shaft Installation

- Set shaft template
- Drive permanent casing using vibro hammer
- Excavation of permanent casing
- Installation of temporary casing by oscillator
- Excavation of temporary casing
- Install reinforcing cage
- Pour tremie concrete while removing temporary casing
Set Shaft Template

- Secondary Template
- Upper Template
- Lower Template
- Spud Pile
Drive Permanent Casing

APE 400B Vibratory Hammer

Paint markings at each foot verify depth of casing as it is being installed.

River bottom EL approx. -40’ East, 5’ West
A vibratory hammer is used to vibrate the casing into the ground.
An oscillator works like someone is opening and closing a jar (back and forth)

Speed has been accelerated
Excavate Temporary Casing

- 90" Temporary Casing
- Hammer Grabs
- Bottom of Permanent Casing

West - 175  East - 180
Pour Tremie Concrete

- 41.8’
- 10’ Min. Embed
- 30’ of temp. casing removed
- Maintain 4” Slump for Duration of Pour (~8 hours)
Base Grouting
Footing Cofferdam Structure

Piles and trestle are installed
Install Soffit Panels
Install Bracing Frame

- Install first tier of brace frame
Erect Pre-Cast Wall

- Install pre-cast walls
- Connect to soffit panels and first tier brace frame
Install Jacking System

- Install jacking system with permanent hangers
- Lower structure to facilitate 2\textsuperscript{nd} & 3\textsuperscript{rd} tier bracing installation
Install Additional Brace Frames

- Install 2\textsuperscript{nd} and 3\textsuperscript{rd} tier brace frame.
Install Follower Sheeting

• Install sheet pile
Lower Structure

- Lower structure to final elevation
- Lock off hangers
Pour Concrete Seal

- Install 8 foot concrete seal
Dewater Structure

- Install pump.
- Remove water
Remove Hangers and Cut Casing

- Remove hangers
- Cut casing
Place reinforced pile cap concrete
Place Pedestal Concrete

- Place pedestal reinforcing and concrete lift 1
- Restrut as required
Place Pedestal Concrete Lift 2

• Place pedestal concrete lift 2
Remove Cofferdam

- Remove sheeting
- Remove Bracing
- Patch blockouts
Audubon Bridge Links

http://flatironcorp.oxblue.com/jjab/

http://www.timedla.com/bridge/audubon/overview/

GregShafer@parsons.com