I-10 TWIN SPAN REBUILDING PROJECT

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Tulane Engineering Forum
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1. EMERGENCY BRIDGE REPAIRS

2. LONG TERM BRIDGE REPLACEMENT
• EACH PARALLEL BRIDGE – 5.4 MILES, YR. COMPLETED = 1963
• LOW LEVEL 65’ L x 43’ W MONOLITHIC PRESTRESSED PRECAST GIRDER SPANS
• 54” PRECAST PRESTRESSED CYLINDER PILE
• EACH 65’ SPAN DEAD LOAD APPROX. 300 TONS
• 250 FT. HIGH LEVEL STEEL NAVIGATIONAL SPAN
Surge Force
Fender System Pontchartrain Causeway Bridge
STORM SURGE FORCES

SURGE LEVEL

NORMAL LAKE LEVEL

INCREASE IN LAKE LEVEL

SPAN BUOYANCY, NO VENTING

CORROSION OF CONNECTIONS
CONNECTIONS FAILS

UPWARD PRESSURE
500 – 1000 PSF VARIES BY BRIDGE HEIGHT
(USED FOR DESIGN OF NEW BRIDGE)

FAILURE OF BRIDGE RAIL

SURGE FORCE
400 PSF
SOME SPANS IN LAKE, SOME RESTRAINED BY CAP RISERS
EASTBOUND BRIDGE - lost 38 spans, 170 spans shifted alignment, 130’ barrier railing damaged.

WESTBOUND BRIDGE - lost 26 spans, 303 spans shifted alignment, 13,910’ of bridge railing damaged.

BOTH BRIDGES - major bearing damage.
SPANS SHIFTED OFF CAPS

MOVEMENT STOPPED BY RISERS, BUT CAUSED GIRDER AND CAP DAMAGE
SPAN DISPLACEMENT BY ONE RISER SPACING
TYPICAL BARRIER DAMAGE FROM BACKSIDE SURGE FORCE

TYPICAL BEARING DAMAGE AT GIRDER ENDS OF TWO SPANS
REPAIRS

• REESTABLISH MAJOR ROUTE INTO NEW ORLEANS FOR RECOVERY.

• ACCELERATED COMPLETION FOR BRIDGE INSPECTION, BID PACKAGE AND REPAIRS AS PER GOVERNOR.

• MEET WITH FLA. DOT TO DISCUSS I-10 ESCAMBIA BRIDGE – HURRICANE IVAN.
REPAIR SCHEDULE

• Hurricane Katrina hit Monday, August 29, 2005.

• Bridge Inspections started immediately.

• Proposal developed and pre-bid mtg. held by DOTD, low bidder announced on Wednesday, September 7.

• Contractor NTP on Monday, September 12, Fourteen days after the hurricane made landfall.

• Three Phases – East bound, West Bound and Long term Maintenance
BID RESULTS

BOH BROTHERS - $30.9 M, ESTIMATE $53M

2nd bidder, $40 M

3rd bidder, $90 M

TWO OTHER CONTRACTORS DROPPED OUT.

CONTRACTOR RISKS

LABOR, EQUIPMENT & HOUSING AFTER STORM

DESIGN FOR REPAIRS DURING CONSTRUCTION

REMOVAL OF SPANS IN WATER

LEARNING CURVE FOR SPMT

INSPECTION REPORTS GIVEN

Immediately Start planning and design for new bridge
PHASE 1: REPAIR EASTBOUND ROADWAY

- Move spans from WB to fill gaps on EB
- Realign and repair missing spans on EB
- 45 days, completed in 34 days (Opened October 14, 2005)
- Construct road crossovers & Open EB two way traffic
Span Realignment & Replacement

SPMT - SELF PROPELLED MODULAR TRANSPORTERS - Mammoet
LIFTING SPANS

SPAN SWAPS FROM WESTBOUND TO EASTBOUND BRIDGE
REALIGNMENT OF SPANS BY SPMT

REALIGNMENT BY JACK AND SLIDE METHOD
PHASE 2: REPAIR WESTBOUND ROADWAY

- Replace WB spans with ACROW 700 Series bridging & realign spans.
- Open WB lanes to one way traffic (Date opened January 6, 2006)
- Convert EB lanes to one way traffic
• Periodic repairs to the Acrow Spans due to truck overloads.
• Construction of a weigh in motion station north of the westbound bridge.
• Better anchorage of the existing spans to resist future storms.
• Existing bridge was load posted for 20 T – 35 T.
NEW BRIDGE CRITERIA

• FAST TRACK DESIGN AND LETTING DUE TO BRIDGE CONDITION
• OFFSET ALIGNMENT TO KEEP EXISTING TRAFFIC MAINTAINED
• STORM SURGE PROTECTION BY INCREASED ELEVATION ON BRIDGE
• LOWER TRANSITION SPANS DESIGNED FOR SURGE FORCE
• INCREASE CAPACITY, 3 - 12 FT. LANES AND 2 - 12 FT. SHLDRS.
• ITS SYSTEM
• 100 YEAR DESIGN LIFE – ADVANCED MATERIALS - HPC
• HIGH STRENGTH CONCRETE SPANS
• OPEN BRIDGE RAIL TEST LEVEL 4 SYSTEM
• VESSEL IMPACT COLLISION
• REDUCE R/W AND ENVIRONMENTAL IMPACTS
• BAYOU SAUVAGE WILDLIFE RESERVE & US 11 INTERCHANGE
• AASHTO LRFD DESIGN CODE & PERMIT VEHICLE
CONSTRUCTION PHASING

Construction Contract 1, (S.P. 450-17-0025)
Construction Contract 2, (S.P. 450-17-00xx)

Transition Spans

CROSSOVER
BID ALTERNATES CONTRACT 1
NEW LOW LEVEL BRIDGE

**Alternate A**
Precast 135 ft. 78” BT HPC Prestressed Girders with pile bents and 36” Precast Piles.

**Alternate B**
154 ft. Segmental Concrete Box Girder using span by span erection on pile bents and 36” Precast Piles.

**Low level transition**
Flat Slabs and Type III beams, no alternate.
Precast Piles

Typical Section

Q W.B. Bridge

62’-6”

12’-0” Shldr.

12’-0” = 36’-0” Shldr.

3 Lanes @ 12’-0”

PGL 2.50%

Varies (53’-6” Max.)

Q Construction

Q E.B. Bridge

62’-6”

12’-0” Shldr.

12’-0” = 36’-0” Shldr.

3 Lanes @ 12’-0”

2.50%

PGL
Slab Span
Transition Anchorage Details

5 SLAB SPANS @ 30'-0" = 150'-0" CONTINUOUS UNIT

30'-0" (TYP.)

EXPANSION FIXED FIXED FIXED EXPANSION

SLAB REINFORCEMENT

SHEAR KEY

SPAN ANCHOR ASSEMBLY (DETAILS)

36" # PILE (OR 48" DRILLED SHAFT)

EXPANSION BENT
SLAB TO CAP CONNECTION DETAILS

#5 CONNECTION STIRRUP @ 1'-6" SPS

CAP REINFORCEMENT

36" # PILE (OR 48" DRILLED SHAFT)

FIXED BENT
SLAB TO CAP CONNECTION DETAILS
154.5 FT. SEGMENTAL LOW LEVEL ALTERNATE

Typical Section

Q W.B. Bridge — Varies (53'–6" Max.) — Q E.B. Bridge

62'–6"

Q W.B. Bridge — 12'–0" — 3 Lanes @ 12'–0"

Shldr. 12'–0" = 36'–0" Shldr.

Q Girder — PGL — 2.50%

62'–6"

Q E.B. Bridge — 12'–0" — 3 Lanes @ 12'–0"

Shldr. 12'–0" = 36'–0" Shldr.

Q Girder — PGL — 2.50%

9'–0 38"
LOW LEVEL SEGMENTAL
Superstructure Erection Scheme

PHASE I - SEGMENT PLACEMENT

PHASE II - STRESSING LONGITUDINAL TENDONS

PHASE III - TRUSS ADVANCEMENT
CONTRACT NO. 2 - 1.1 MILE HIGH SPAN PORTION

- **ALTERNATE A1**
  BT78 & Steel Plate Girders with CIP Columns

- **ALTERNATE A2**
  Segmental Box Girders with CIP Columns

- **ALTERNATE A3**
  Segmental Box Girders with Precast Columns
Steel Span Typical Section

ASTM Grade 50W steel 90” Web

112'-6” to adjacent bridge CL

62'-6”

12'-0” 3 Lanes @ 12'-0” = 30'-0” 12'-0”

Shoulder

Shoulder
Alternate A2 – Cast-in-Place Piers

Alternate A3 – Precast Piers
PHASE I – MODIFIED BALANCED CANTILEVER CONSTRUCTION (CANTILEVER 1)

COMPLETE SIDE SPAN #1

PHASE II – MODIFIED BALANCED CANTILEVER CONSTRUCTION (CANTILEVER 2)

PHASE III – MAIN SPAN CONTINUITY (COMPLETED MAIN SPAN UNIT)

Main Span Erection Scheme
SURGE Modeling Data Tools

DELFT 3D SWAN (Delft Hydraulics, Netherlands) to develop the numerical model

Boussinesq Wave Model (Danish Hydraulic Institute) for potential wave set up at the bridge

Statistical analysis of wind speed and direction of 324 hurricanes and tropical storms

ADCIRC (Finite Element Hydrodynamic Model, LSU & USACE) to perform storm modeling of Hurricane Katrina and hypothetical stronger storms
Instantaneous Wave Forces on Bridge Span

Span Cross-section

Entrapped Air

Storm Water Level

Mean Water Level

Bed

\[ \eta_{\text{max}} \]

\[ d \]

\[ d_s \]

Horizontal Forces
- \( F_{\text{drag}} = \) Drag Force
- \( F_{\text{inertia}} = \) Inertia Force
- \( F_{\text{cam}} = \) Change in Added Mass Force

Vertical Forces
- \( F_{\text{drag}} = \) Drag Force
- \( F_{\text{inertia}} = \) Inertia Force
- \( F_{\text{cam}} = \) Change in Added Mass Force
- \( F_b = \) Buoyancy Force
Hurricane Katrina
~ 100-year Event
Max. Wave Crest Elevation= 22.8’
Hurricane Katrina West
~ 500-year Event
Max. Wave Crest Elevation = 30.6'(NAVD88)
• Where possible, the bridge finished grade will be elevated beyond the 500 year event (30.6 ft. for low concrete & 38.17 ft. for FG low level bridges)

• For transition spans close to the shore, spans will be designed for the 100 year event and anchored accordingly.
LRFD Load Combinations

- The AASHTO LRFD specifications do not directly address the wave surge load condition.

- The long duration load caused by the surge could be applied as a Strength III case and the short impact load could be treated as an extreme event load.
### Load Combinations and Load Factors

(Per AASHTO LRFD Bridge Design Specifications Table 3.4.1-1 unless noted otherwise)

<table>
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<th>Limit States</th>
<th>DC Max</th>
<th>DC Min</th>
<th>DW Max</th>
<th>DW Min</th>
<th>LL</th>
<th>IM</th>
<th>WA</th>
<th>S¹</th>
<th>S²</th>
<th>WS</th>
<th>WL</th>
<th>FR</th>
<th>TU</th>
<th>CR</th>
<th>SH</th>
<th>TG</th>
<th>SE</th>
<th>CV</th>
<th>SC³</th>
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<td>1.35</td>
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<td>0.5</td>
<td>1/2</td>
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<td>-</td>
<td>1.4</td>
<td>1.0</td>
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<td>0.5</td>
<td>1/2</td>
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<td>Strength V</td>
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<td>1.35</td>
<td>1.0</td>
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<td>-</td>
<td>0.4</td>
<td>1.0</td>
<td>1.0</td>
<td>0.5</td>
<td>1/2</td>
<td>-</td>
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<td>Extreme II³</td>
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<tr>
<td>Extreme III³</td>
<td>1.25</td>
<td>0.9</td>
<td>1.5</td>
<td>0.65</td>
<td>1.75</td>
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<td>Extreme IV³⁵</td>
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<td>0.9</td>
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<td>0.65</td>
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<td>-</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
<td>1.4</td>
<td>1.0</td>
<td>-</td>
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<td>0.7</td>
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<td>1.5</td>
<td>0.65</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>1.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.0³</td>
</tr>
</tbody>
</table>

### Notes

1. Quasi-Static Storm Surge Forces
2. Dynamic or Impact Storm Surge Forces
3. Scour Depth
4. 180% of the Scour Depth
5. Per NCHRP Report 489 “Design of Highway Bridges for Extreme Events”.
6. 60% of the Scour Depth
7. Apply wind load on structure (WS) to surfaces where storm surge forces (S) are absent.
VESSEL IMPACT RESISTANCE

- Model all Span Units and Substructure Using the Florida Multi-Pier Program.

- Design Loads Obtained by Vessel Collision Report and Surge Model.
## Vessel Impact Loads

<table>
<thead>
<tr>
<th>Bent</th>
<th>Distance to Center of Channel (ft)</th>
<th>Design Vessel</th>
<th>Impact Force Parallel to Bent (kips)</th>
<th>Impact Force Perpendicular to Bent (kips)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Loaded</td>
<td>Unloaded</td>
</tr>
<tr>
<td>175 and 176</td>
<td>125</td>
<td>Oversize Tanker</td>
<td>2642</td>
<td>2182</td>
</tr>
<tr>
<td>174 and 177</td>
<td>325</td>
<td>Oversize Tanker</td>
<td>2505</td>
<td>2145</td>
</tr>
<tr>
<td>173 and 178</td>
<td>460</td>
<td>Oversize Tanker</td>
<td>2419</td>
<td>2124</td>
</tr>
<tr>
<td>172 and 179</td>
<td>595</td>
<td>Oversize Tanker</td>
<td>2338</td>
<td>2104</td>
</tr>
<tr>
<td>171 and 180</td>
<td>730</td>
<td>Oversize Tanker</td>
<td>2264</td>
<td>1837</td>
</tr>
<tr>
<td>170 and 181</td>
<td>865</td>
<td>Oversize Tanker</td>
<td>2198</td>
<td>1438 (Note 1)</td>
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<tr>
<td>169 and 182</td>
<td>1000</td>
<td>Oversize Tanker</td>
<td>2142</td>
<td>1438 (Note 1)</td>
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<tr>
<td>168 and 183</td>
<td>1135</td>
<td>Oversize Tanker</td>
<td>2097</td>
<td>1438 (Note 1)</td>
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<tr>
<td>Other Bents</td>
<td>&gt;1140 (3 x LOA)</td>
<td>Empty Barge</td>
<td>96</td>
<td>96</td>
</tr>
</tbody>
</table>

**Vessel Impact Speed, V:**

1. Use 2 feet per second for the locations beyond 3xLOA from the center of the channel.
2. Use 7.3 feet per second in the navigation channel.
3. The speed beyond the navigation channel shall be linearly reduced from 7.3 fps to 2 fps as a function of the distance from the center of the channel.

**Notes:**

1. For bents located within 3xLOA, the minimum impact force shall be 1438 kips which is the empty standard hopper barge impact force at vessel impact speed of 12 feet per second per storm surge analysis report (Appendix A).
2. The vessel impact forces shall be applied to the locations specified in AASHTO LRFD Bridge Design Specification Section 3.14.14.
Provide Minimum 100 Years of Service

- **Combination of High Performance Concrete (1000 coulombs)** and additional concrete cover are used to improve the durability of the bridge.

- Previously used HPC mix designs, including the Cooper River and Confederation bridges, are studied.

- Life-365 software used as a tool for service life.
<table>
<thead>
<tr>
<th>Project Mix</th>
<th>Cementitious Content (LB/CY)</th>
<th>Water/Cement Ratio</th>
<th>Silica Fume Percentage of Total C.M.</th>
<th>Class F Fly Ash Percentage of Total C.M.</th>
<th>B.F. Slag Percentage of Total C.M.</th>
<th>Reinf. Type</th>
<th>Min. Comp. Strength at 28/56 days (psi)</th>
<th>Required Chloride Permeability at 56 days (ASTM C1202) (coulombs)</th>
<th>Required Diffusion Coefficient at 28 days (x 10-12 m/s2) (ASTM C1556)</th>
<th>Design Life (See Note) (years)</th>
<th>Minimum Cover (inches)</th>
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</thead>
<tbody>
<tr>
<td>LaDOTD Girders</td>
<td>987</td>
<td>0.25</td>
<td>0.0%</td>
<td>30%</td>
<td>0%</td>
<td>Uncoated</td>
<td>10000</td>
<td>2000</td>
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<td>51.7</td>
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<td>Virginia Girders</td>
<td>827</td>
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<td>0%</td>
<td>Uncoated</td>
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<td>n/a</td>
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<td>5.0%</td>
<td>22%</td>
<td>0%</td>
<td>Uncoated</td>
<td>10000</td>
<td>n/a</td>
<td>n/a</td>
<td>73.4</td>
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<td>Nebraska Deck</td>
<td>825</td>
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<td>0.0%</td>
<td>9%</td>
<td>0%</td>
<td>Uncoated</td>
<td>8000</td>
<td>1800</td>
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<td>1000</td>
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<td>28%</td>
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<td>Uncoated</td>
<td>4000</td>
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<td>Confeder. Mix</td>
<td>801</td>
<td>0.30</td>
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<td>9.5%</td>
<td>0%</td>
<td>Uncoated</td>
<td>8700 @ 91 d</td>
<td>1000 .48@ 6 mo.</td>
<td>n/a</td>
<td>54.4</td>
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<td>43%</td>
<td>0%</td>
<td>Uncoated</td>
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<td>500</td>
<td>n/a</td>
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<td>Cooper River Sup.</td>
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<td>20%</td>
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<td>Uncoated</td>
<td>4000</td>
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<td>20.4</td>
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<td>BR 1</td>
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<td>Uncoated</td>
<td>6797</td>
<td>1257</td>
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<td>30.1</td>
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<td>0%</td>
<td>50%</td>
<td>Uncoated</td>
<td>8974</td>
<td>1126</td>
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<td>610</td>
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<td>3.0%</td>
<td>3%</td>
<td>25%</td>
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<tr>
<td>Four Bears Mix</td>
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<td>15%</td>
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<td>Uncoated</td>
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<td>n/a</td>
<td>n/a</td>
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</tr>
<tr>
<td>Our Spec (FA1)</td>
<td>750</td>
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<td>As req’d.</td>
<td>15%</td>
<td>0%</td>
<td>Uncoated</td>
<td>6000</td>
<td>1500 0.85</td>
<td>106.6</td>
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</tr>
<tr>
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<td>As req’d.</td>
<td>20%</td>
<td>0%</td>
<td>Uncoated</td>
<td>6000</td>
<td>1500 1.1</td>
<td>103.3</td>
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<tr>
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<td>25%</td>
<td>0%</td>
<td>Uncoated</td>
<td>6000</td>
<td>1500 1.4</td>
<td>101.9</td>
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</tr>
<tr>
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<td>As req’d.</td>
<td>30%</td>
<td>0%</td>
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<td>6000</td>
<td>1500 1.65</td>
<td>102.4</td>
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<td>1.5</td>
</tr>
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<td>As req’d.</td>
<td>0%</td>
<td>25%</td>
<td>Uncoated</td>
<td>6000</td>
<td>1500 0.85</td>
<td>106.6</td>
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</tr>
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<td>As req’d.</td>
<td>0%</td>
<td>30%</td>
<td>Uncoated</td>
<td>6000</td>
<td>1500 1.1</td>
<td>103.3</td>
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<td>As req’d.</td>
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<td>35%</td>
<td>Uncoated</td>
<td>6000</td>
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<td>As req’d.</td>
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<td>1500 1.65</td>
<td>102.4</td>
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</table>
CONTRACT #1 – LOW LEVEL SPANS AND ROADWAY

- Letting Date: April 2006 (6 month design schedule)
- 44,547’ of bridge – low level trestle
- Boh Brothers, NTP on June, 2006, $355 M
- BT alternate chosen
- Change Order issued for Transition spans near each end.

CONTRACT #2 - NAVIGATION MAIN SPAN

- Letting Date: November 2006
- 11,560’ of main navigational span bridge
- Traylor/Kiewit/Massman JV, NTP on Jan. 2007, $167M
- BT and Steel Girder Alternate Chosen
Contract Number 1

- All the advanced foundation testing have been completed and pile lengths have been defined for both new bridges.

- Most dredging operations and construction staging areas have been constructed.

- All road way detours have been built including provisions for a third lane during hurricane evacuation.

- Low permeability concrete mixes have been agreed upon.

- Shop drawings have been reviewed for piles, caps, formwork, girders, joints, bearing pads, electrical and ITS equipment.
Contract Number 2

- Pile order lengths have been determined.
- Construction yard is being established.
- Shop drawings for steel girders are under review.
Completion of first WB bridge is planned for March 2009.

Completion of entire project is planned for March 2011.
PROJECT TEAM – EMERGENCY REPAIRS

- BID PACKAGE & SPECIFICATIONS – LA DOTD
- BRIDGE INSPECTION – LA DOTD, VOLKERT & ASSOCIATES
- CONTRACTOR – BOH BROTHERS
- SPMT - MAMMOET
- TEMPORARY BRIDGING – ACROW
- CONSTRUCTION QA FOR DOTD – VOLKERT AND ASSOCIATES
PROJECT TEAM – BRIDGE REPLACEMENT

- DESIGN – LA DOTD
- DESIGN ALTERNATE - FIGG ENGINEERING, BURK KLEINPETER, TRC
- SURGE ANALYSIS – MOFFATT AND NICHOL, LSU
- GEOTECHNICAL – FUGRO
- GEOTECHNICAL TEST PILE PROGRAM – FUGRO & AFT
- CONTRACTOR CONTRACT 1 – BOH BROTHERS
- CONTRACTOR CONTRACT 2 – TRAYLOR KIEWIT MASSMAN JV
- CONSTRUCTION QA FOR DOTD – VOLKERT AND ASSOCIATES
QUESTIONS?

RENDERING OF HIGH LEVEL SPAN