APPENDIX E

(Structures Information)
Preferred Alternative Renderings
PIN 1805.81, Lake Champlain Bridge Replacement NY approach ‘before’ condition.

PIN 1805.81, Lake Champlain Bridge Replacement NY approach ‘after’ condition.
Bridge Option Types
Technical Presentation

January 6, 2010
Lake Champlain Bridge Design Technical Presentation

Presented to NYSDOT, VAOT, & FHWA
January 6, 2010
• Introduction
• Preliminary Bridge Plan
• Overall Design
• Substructure
• Superstructure
• Analysis & Design Methods
• Wind Tunnel Testing
• Bridge Durability
• Special Provisions
• Design Schedule
• Construction
Network Tied Arch

- Composed of a tied arch with a series of inclined hangers that cross another hanger at least twice
- Developed by Per Tveit in the late 1950s
- Primarily axial compression and tension forces
  - Small shear and bending forces
  - Smaller sections, less material
Design Requirements

• Minimum of 75 year design life
• 5% profile grade
• Roadway Vertical Clearance: 17’-0”+
• Navigational Channel Clearance
• Minimize / Eliminate Fracture Critical Members (FCM)
Design Criteria

- Lake Champlain Design Criteria (DRAFT)
- Applicable Design Code
  - AASHTO LRFD Bridge Design Specifications
  - NYSDOT Bridge Manual
  - NYSDOT LRFD Design Specifications
  - NYSDOT Standard Specifications (Blue Pages)
Seismic Design Spectra

2500 Year Return Period Event

1000 Year Return Period Event

Comparison Between Return Periods Site Class "B*

Comparison Between Return Periods Site Class "B*"
Subsurface Profile
Point Load Test and Unconfined Compressive Strength Correlation

\[ \sigma_c = 24 \, l_{(50)} \]
Remolded Undrained Shear Strength vs. Elevation
<table>
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<th>Substructure</th>
<th>Stratum</th>
<th>Strata Thickness (ft)</th>
<th>$\gamma$ (pcf)</th>
<th>$\phi$ (deg)</th>
<th>$s_u$ (psf)</th>
<th>k (pci)</th>
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Notes: $\gamma$-Unit weight, $s_u$-Undrained shear strength, $q_{um}$-UC strength of rock mass, $E_m$-Elastic modulus of rock mass, $\varepsilon_{50}$-Strain at 50% of peak strength, $\phi$-Friction angle, k-Soil modulus for lateral analysis
Foundations

- Drilled Shafts
- Precast Pile Caps
Piers

- Ice Breaking Piers
  - Confederation Bridge, Canada
Piers

• Cast-in-Place Reinforced Concrete Piers
Approach Span Conceptual Framing Plan

- 5 Steel Girder System
- Precast Concrete Deck Panels
  - Roadway & Sidewalk
- Diaphragm Spacing at 25’-0”
- Deck From 47’-8” to 57’-0” wide
Arch Span Conceptual Framing Plan

- Precast concrete deck panels composite with floorbeams
- Floorbeams spaced at 12’-0”
- Cantilever brackets outside of tie girders
- Lateral bracing
- 57’-0” total width
Arch / Girder Connection (Knuckle Joint)

- Conservative – additional steel thickness
- Only area exposed to road salts
  - Weathering steel used for Network Tied Arch
  - Additional material coatings
Concrete Deck

- Precast Concrete Panels with Cast-in-Place Closures

- Post Tensioned Arch Span
  - Flat anchorage system
Bearings

- Elastomeric Bearings
  - Expansion Bearings at Arch Span

- Disk Bearings
  - Fixed Bearings at Approach Spans
  - Expansion Bearings at Abutments
Joints

- At arch: Compression Joints

- At abutments: Modular Joints
Cable Hangers

- Freyssinet H1000 System
- UHMW Cable Connector Assemblies

**Upper fork anchorage**
The strands in this anchorage are anchored by swages in a block screwed to a fork facing. The latter, made of machined steel, is hinged to the structure with a pin.

**Lower fork anchorage**
The cable is fully prefabricated with both anchorages. The strands are anchored with swages in a block screwed to a fork creating an articulated connection. This machined steel fork has a turnbuckle for adjustment and tensioning.
FB Pier Model

- Foundation modeling
Microstation 3D CAD Model
T187 Model

- Beam Elements
  - Approximated Section Properties

- Support conditions:
  - 1 Pinned
  - 1 Roller
LUSAS Global Model

- Beam Elements
  - Arch
  - Tie Girder
  - Floorbeams
- Bar Elements
  - Cables
- Truss Elements
  - Bracing
LUSAS Rigid Frame Model

- Steel – Shell elements
- Concrete – Solid elements
LUSAS Rigid Frame Model

- Preliminary Stress Analysis

- Preliminary Non-linear Buckling Analysis
Force Balance Tests

Wind Tunnel Testing

[Images of wind tunnel test setups]
Ice Breaker Design

- Factor in pier shape determination
- Granite panels bolted to inclined faces
- U.S. Army Cold Regions Research and Engineering Laboratory (CRREL)
  - Possible collaboration in design
  - Icing predictions

Figure 3 Influence of Slope Angle and Friction on Ice Sheet Load – Constant Diameter
Material Coatings

- Metallizing (Zinc and/or Aluminum)
  - Steel superstructure
  - Spray application
    - Can be applied in most shop and field environments
    - “Cold process”; does not cause distortion of welds or steel from high temperatures
    - Higher initial cost than painting, but lower life cycle costs
Material Coatings

- Galvanizing Reinforcing Bar
  - Enhanced corrosion protection
Stay Cables

- Greased & Sheathed Stay Cables (Nested Protection)
- Blisters above roadway
- HDPE Pipe anchorages (subject to Leak Test)
Stay Cables

- Leak Test – 96 hours
Stay Cables

**Durability**

**Axial Fatigue Tests**

PTI Recommendations

0.36 to 0.45 fu **fatigue** stress range for 2 million cycles (82, 119 & 156)
2% wire fractures allowed

**Static strength** > 0.95 Pu (82 & 156)

156-0.6 Strand Test:

Fatigue Loads:
3290 to 4114 kips

Static Strength:
8685 kips

Abrasion at SS pipe joint
Structural Health Monitoring

- Possibility for permanent sensors
  - Accelerometers
  - Inclinometers
  - Monitor structural behavior

Confederation Bridge Sensors

Figure 5: Typical Pier Arrangement Showing Instrumentation
Anticipated Special Provisions

- Concrete
  - Post-tensioned Deck
- Steel
  - Superstructure
    - Metallizing
  - Stay Cables
    - Testing
    - Erection
    - Corrosion Protection
- Construction
  - Heavy Lifting
  - Float-in
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<th>LAKE CHAMPLAIN BRIDGE REPLACEMENT DESIGN SCHEDULE</th>
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Construction Methods

- Float-in arch span
  - Fremont Bridge
  - Providence River Bridge

Fremont Bridge
Providence River Bridge
Infiernillo Bridge
Construction Methods

- Heavy Lifting Technique

Carquinez Bridge

Eisenbahn Bridge

Infiernillo Bridge

Fremont Bridge
Construction Schedule

LAKE CHAMPLAIN BRIDGE CONSTRUCTION SCHEDULE

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<td>Mobilization - Foundations/Pile Caps</td>
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<td>Approach Span Superstructures</td>
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Bidding

- 50% Plans Released to Bidders
  - February 16, 2010
- PS&E Plans Released to Bidders
  - Excludes: Bar lists, haunch tables, …
  - Mid-March
- Addendum 1 Released to Bidders
  - Bar lists, haunch tables, …
  - Early April
- Bids received
  - Mid-April
Maintenance and Inspection

- Future wearing surface design provision
- Inspect above deck arch from deck mounted manlift
- Inspect below deck system from barge mounted manlift