ACEC Engineering Excellence Award

HAKS Engineers Presentation

Gusset Plate Inspections and Evaluations

Gold Star Bridge over Thames River

November 30, 2009
ACEC Engineering Excellence Award

Gusset Plate Inspections and Evaluations

What is a Gusset Plate?
Connection Plate

Why Gusset Plate Analysis and Evaluation?
Became Area of Concern Due to 2007 Bridge Failure

Client Needs?
Comply with New FHWA Requirements

Client Concerns?
Safety of Steel Truss Bridges, Serviceability and Continued Short-Term and Long-Term Use
Background / Project Need

- Collapse of MN I-35W Bridge over Miss. River (8-01-2007)
  * (8) Lane, Multi-Span Steel Truss-Arch Bridge
  * ADT = 140,000    * 13 Deaths and 145 Injuries

- FHWA Investigations Conclude Collapse is Due to Gusset Plate Failure and other Contributing Factors

FHWA & NTSB Issue New Guidelines and Detailed Analysis Procedures.

- FHWA Turner-Fairbank Report (1-11-08)
- NTSB Safety Recommendations (1-15-08)
- FHWA Technical Advisory (1-15-08)

  “… required owners to check gusset plate capacity to new 2008 FHWA Guidelines on steel truss bridges.”
CLIENT NEEDS
- Evaluate Strength of Gusset Plates on Steel Truss Bridges per 2008 FHWA Guidelines.
- Finish Evaluations by June 30, 2009 Deadline

CLIENT CONCERNS
- General Unfamiliarity of New Guidelines and Regulations Throughout the Industry.
- Lack of Funding and In-House Resources.
- Safety and Serviceability of Steel Truss Bridges. Similarity of Various Gold Star and I-35W Details
- Ability to Meet FHWA June 30, 2009 Deadline.
Assignment from ConnDOT BS&E

Gusset Plate Inspections and Evaluations

1) Gold Star Bridges #03819 (NB) and #02514A (SB)  
I-95 over Thames River, Groton / New London
- ConnDOT very pleased with HAKS Engineers effort & approach
- Awarded HAKS (8) additional steel truss bridges

2) Additional Assigned Bridges Based on Performance:
- Bridge #00901, RT 202 & RT 6 over Housatonic River, New Milford
- Bridge #01343, RT 133 over Housatonic River, Brookfield
- Bridge #01487, RT 177 over Farmington River, Unionville
- Bridge #01500, RT 185 over Farmington River, Simsbury
- Bridge #03846, Drinkwater Place over Metro-North, Greenwich
- Bridge #05159, Romford Road over Bantam River, Washington
- Bridge #00507, RT 816 over Housatonic River, Newtown
- Bridge #03998, Ferry Street over Amtrak, New Haven
Gold Star Bridge over Thames River

Largest Complex Bridge in CT
ADT = 120,000
Length = 6000 ft
Deck Area = 1,000,000 sf

I-95 NB (Br. #03819)
- Built 1943 / Rehab’d 1975
- Spans = 27

I-95 SB (Br. #02514A)
- Built 1973
- Spans = 30

Gusset Plates

22 Deck Truss Spans
Total Length = 7500 ft
Over 500 Truss Nodes
Over 1000 Gusset Plates

Vital Infrastructure Link

I-95 NB
Main Span: L = 540’
140’ Vertical Clearance

I-95 SB
Gusset Plate Evaluations – Gold Star Bridge

**Originality and Complexity**

Inspection/Evaluations Focused on Br#03819

- Original 1940’s Riveted 2-Span Segments
- 1970’s Rehabilitation
- Area’s of Similarity with I-35W Bridge

South Elevation

Snooper Access

Vital Channel
Gusset Plate Evaluations

**Complexity**

- Gusset Plate over Center Pier
- Pin & Hanger Installation (Suspended Span over Main Channel)
- Lower Pin Gusset Plate (Suspended Span over Main Channel)
- Snooper Access
- Climbing Techniques for Difficult Access
Steel Truss Bridge Gusset Plates

Br#507 – New Milford

Br#1343 – Brookfield

Br#3998 – New Haven

Br#1500 – Simsbury
### “Sustainable Design Considerations”

**Gusset Plate Analysis/Evaluation Requirements**

<table>
<thead>
<tr>
<th>Pre I-35W Collapse</th>
<th>Post I-35W Collapse</th>
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<tbody>
<tr>
<td>- Lack of Specific Design Methods and Procedures:</td>
<td>FHWA Bridge Design Guidance (Revised August, 2008)</td>
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<tr>
<td>“gusset plates of ample thickness to resist shear, direct stress and flexure”</td>
<td><strong>New Detailed Analysis &amp; Evaluation Procedures:</strong></td>
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<tr>
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<td>- Shear Capacity</td>
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<td>- Block Shear Rupture</td>
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<td>- Whitmore Section</td>
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<td>- Fastener Capacity</td>
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<td>- Capacity/Demand Ratios</td>
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<td>- Inventory &amp; Operating Ratings</td>
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**Sustainable Design Considerations**

- Lack of Specific Design Methods and Procedures:
  - “gusset plates of ample thickness to resist shear, direct stress and flexure”
“Exceeding Client Expectations”

Partnering with the Client

- Pre-Inspection Planning
- Coordinated Work Effort
- Shared Lane Closures
- “Real-Time” Repairs

reduced paperwork/bureaucracy
deficiencies repaired when found
improved safety

Shared Traffic Control Pattern
“Efficient Maintenance”
“Cost Savings”
“Exceeding Client Expectations”

**Pro-Active Coordination with Client**

- Shared Knowledge of FHWA Advisory.
- Assisted in Interpretation of Guidelines.
- Partnering Meetings to Review Progress and Findings. Share “Lessons Learned”.
- Teamed with Client for Repeated Searches for Archived Information.
Social and Sustainable Design Issues

Re-Allocated Resources to Critical Issues

Inspect for As-Built Details and Section Loss

- **Social Consideration**
  - Ensure Public Use and Safety

- **Sustainable Design**
  - Access and Repair Infrastructure
  - Ensure Continued Long-Term Use

Inspect for and Document Section Losses

Verify Design Details

Painted over Section Losses
Developed Software to Perform Gusset Plate Evaluations per FHWA Guidelines

- Ensured Public Safety and Continued Use
- Allowed for timely completion of evaluations
- Allowed for efficient use of allocated funds

Social and Economic Considerations

Block Shear Ratings

Shear Ratings

Whitmore Section Ratings
Gold Star Bridges #03819 and #02514A
- Over 1000 Riveted Gusset Plate Inspections

Important Findings:
- Section Loss Documentation
- No Cracked or Buckled Gusset Plates
- As-Built Details Verified
- Rehabilitation Details Verified

Very High Client Satisfaction
Exceeding Client Expectations

Pro-Active Effort / Anticipated Client Needs

Developed Software Input-Output Worksheet for 25-page FHWA Analysis Procedures
- efficient completion of gusset plate analysis
- program used by ConnDOT and other Consultants

STAAD Analysis of Deck Truss Spans:
Computed “Static Equilibrium Loading”
- exceeded FHWA requirements
- increased precision
- eliminated un-necessary conservatism
Project Findings and Conclusions

Bridge Ratings Results

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<tr>
<th>Capacity/Demand Ratio:</th>
<th>As-Built</th>
<th>As-Inspected</th>
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<td>1.12 (min)</td>
<td>0.80 (min)</td>
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- Partnered with Client to Assist with Accessing Deficiencies and Prioritizing Rehabilitation

Important Findings

- Structural Adequacy of Truss Gusset Plates
  no significant “as-built” areas of concern

- Documented Items for Short-Term Repairs
  (1) gusset plate repair being progressed

- Identified Issues to Ensure Long-Term Use
QUESTIONS