9D - BRIDGE INSPECTION

9:30 – 10:00 AM

Summary of Safety Inspection Practices for Bridges with Fracture Critical Members

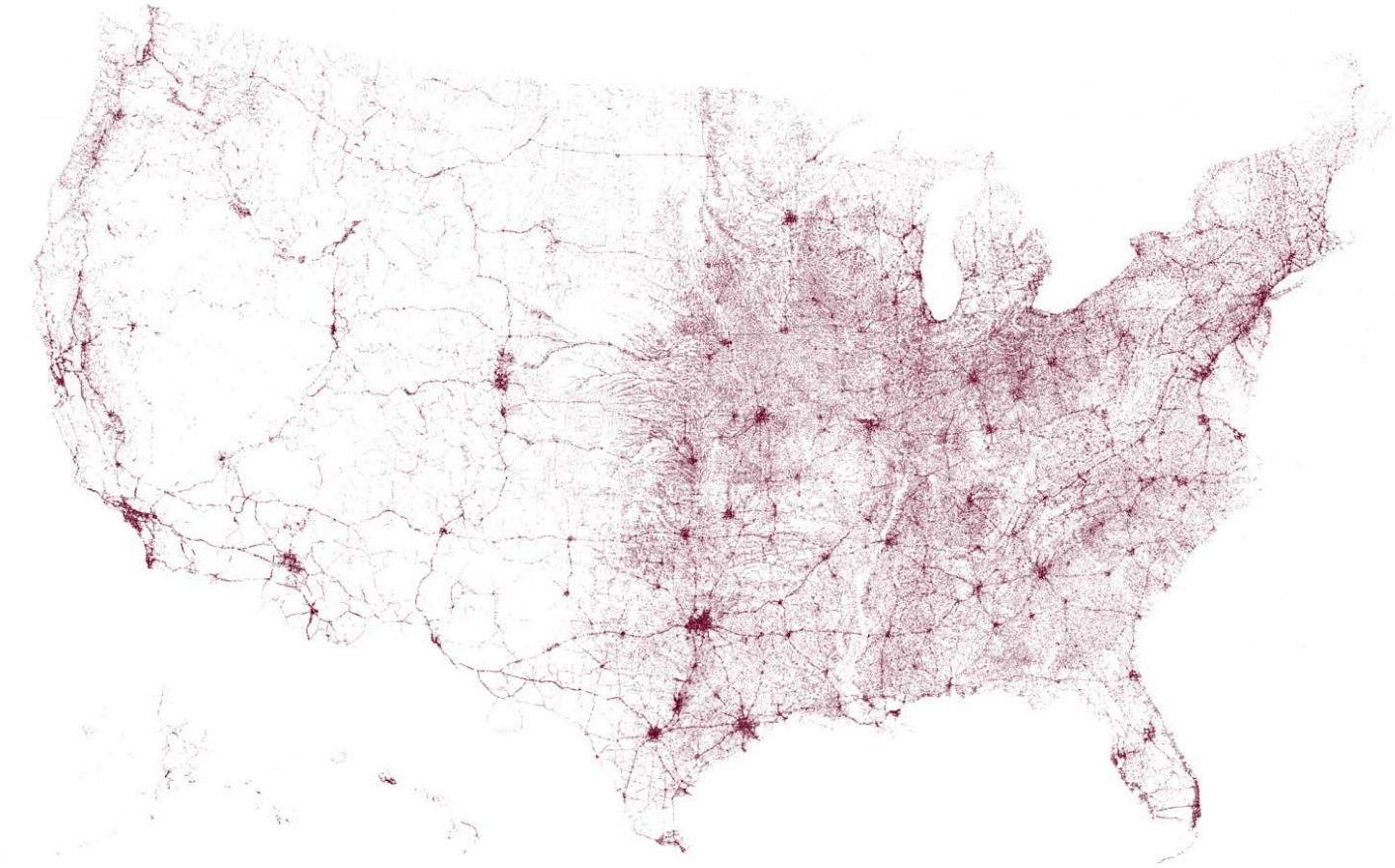
Western Bridge Engineers' Seminar

Summary of Safety Inspection Practices for Bridges with Fracture Critical Members

Brian Leshko, PE

Every bridge in America

1 dot = 1 bridge



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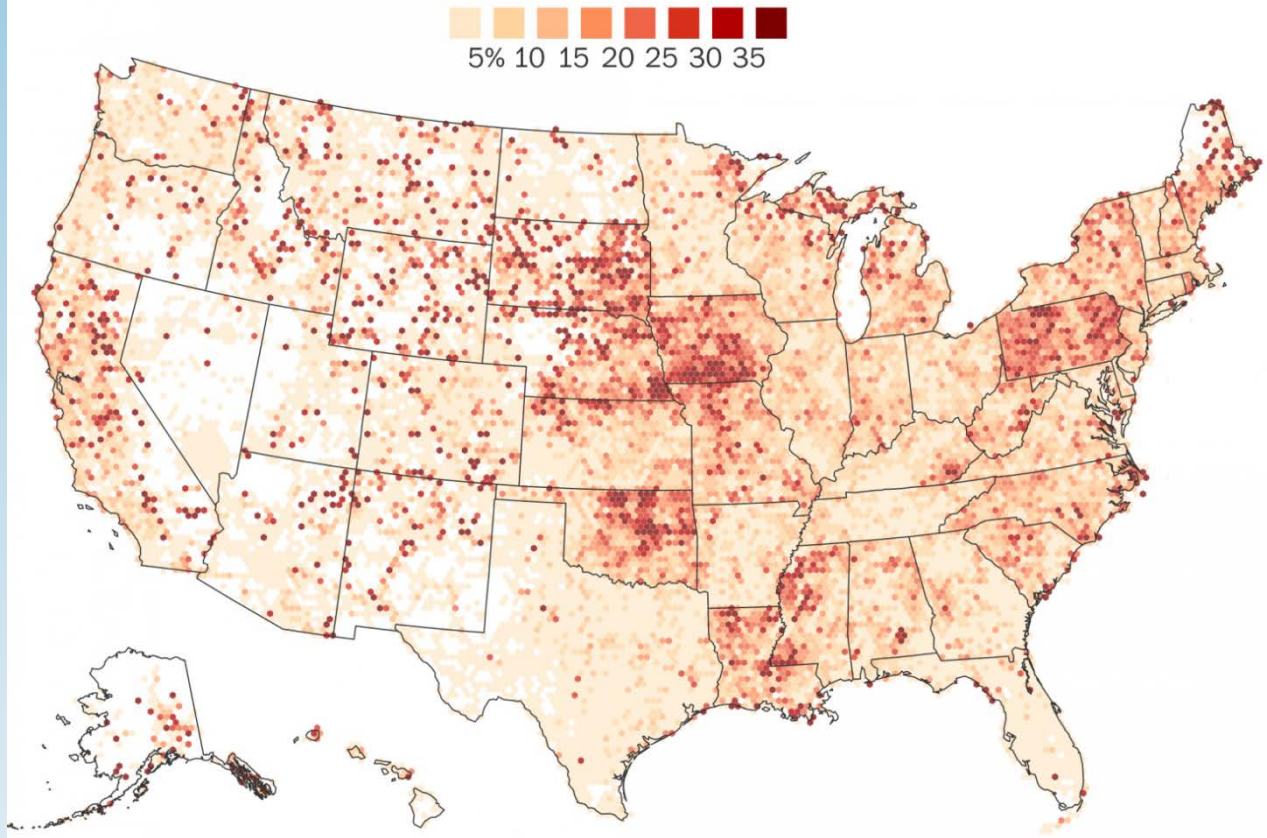
Source: Federal Highway Administration

America's most dangerous bridges

Percent of bridges rated "structurally deficient"



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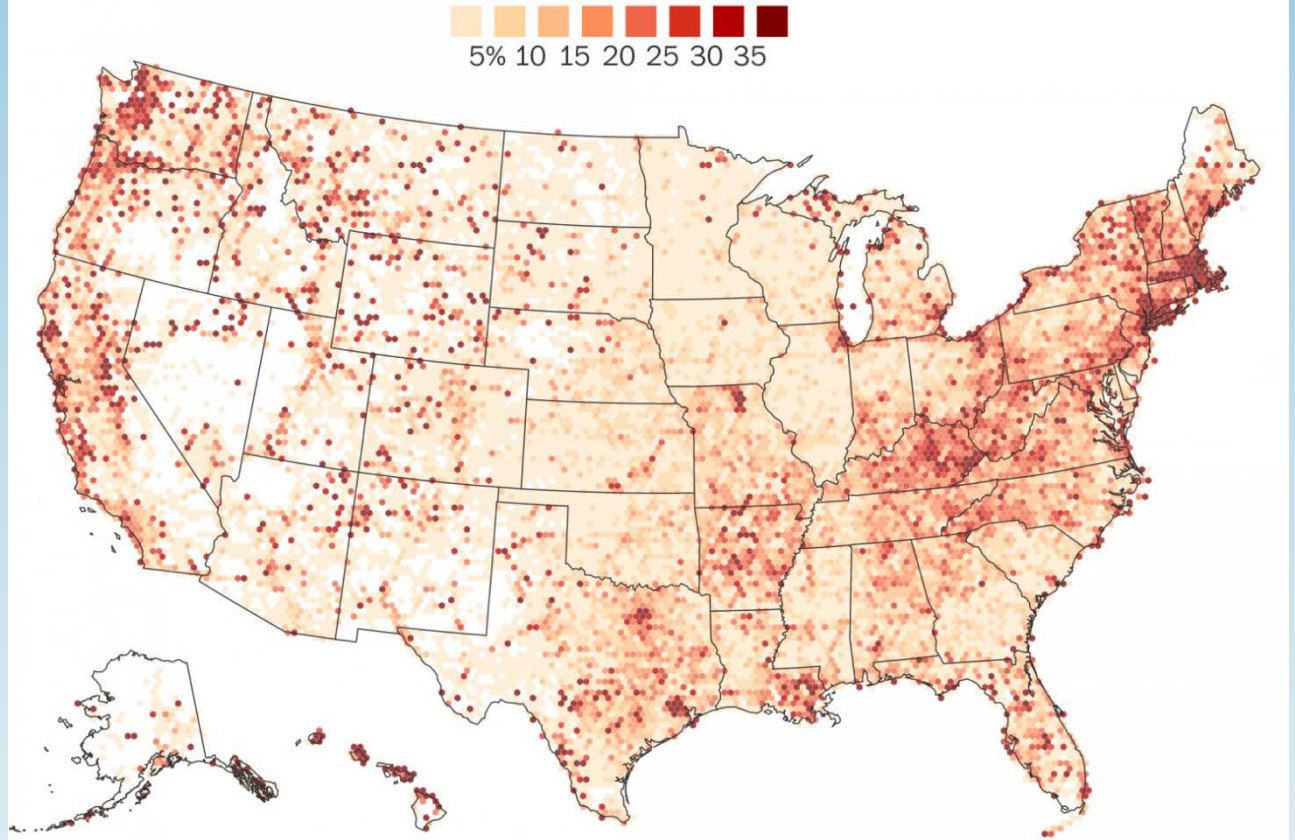
Source: Federal Highway Administration

America's outdated bridges

Percent of bridges rated "functionally obsolete"



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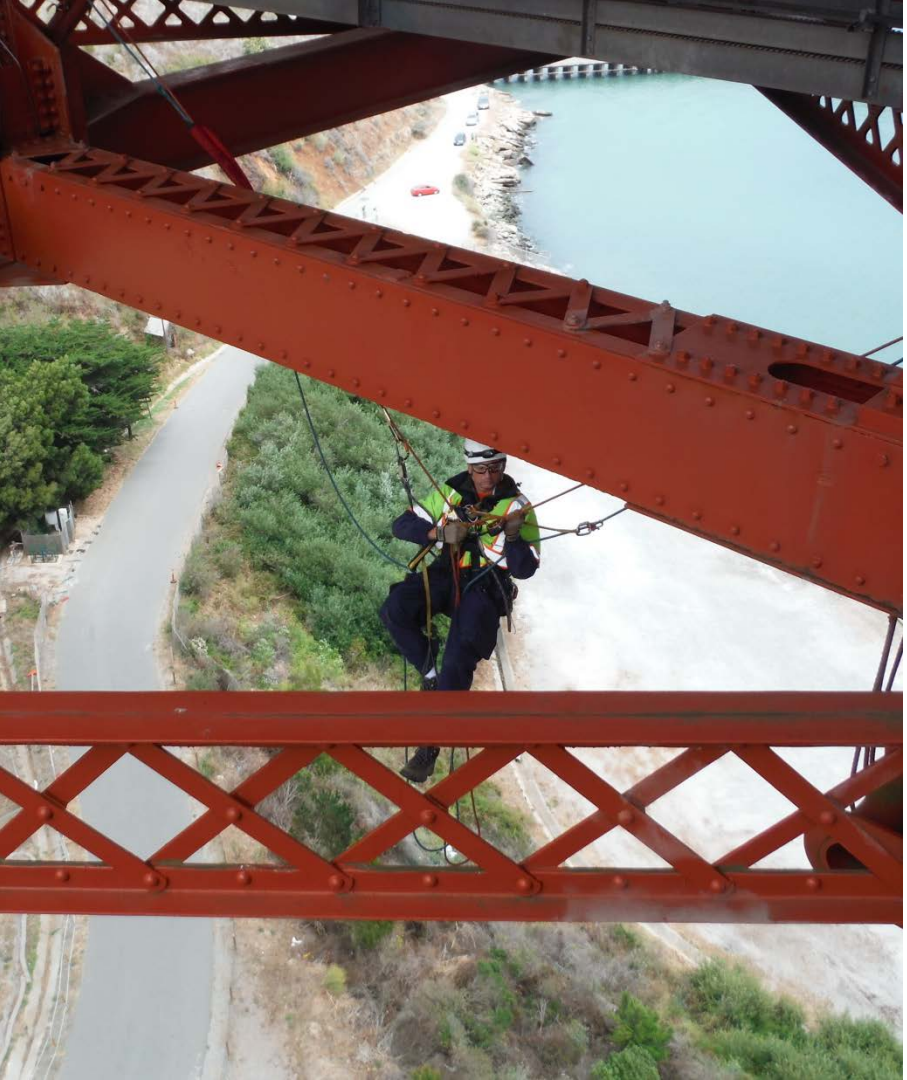
Source: Federal Highway Administration

U.S. Department of Transportation
Federal Highway Administration

Final

Independent Review of *Safety Inspection Practices for Bridges with Fracture Critical Members*

February 2013



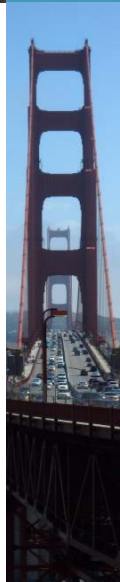
01 Background & Objectives

02 Introduction

03 Findings
- Common Areas of Good Practice
- Common Areas of Improvement

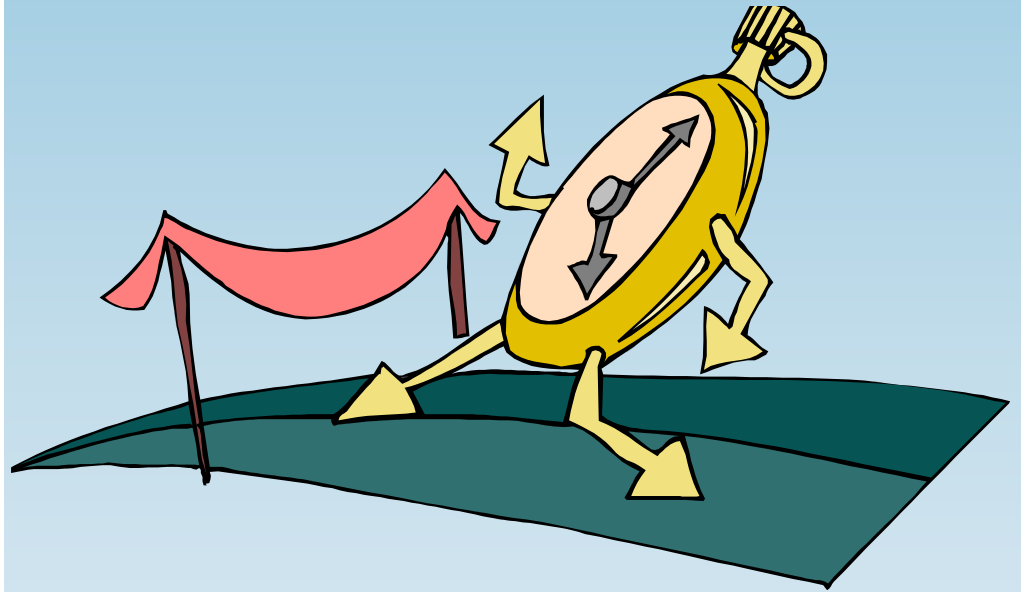
04 Conclusions

01 Background & Objectives



Background

- The Federal Highway Administration (FHWA) contracted with HDR to review the current state of highway bridge inspection practice specific to bridges with fracture critical members (FCMs).
  - General Services Administration (GSA) Delivery Order: Bridge Safety Technical Support Services for the FHWA Office of Bridge Technology (OBT)
  - Base Year (2011) with extensions through March 2013



Background

- Based on a statistical sample of 94 bridges from the National Bridge Inventory.
  - level of confidence of 80%
  - margin of error of 15%
- Various categories of bridges were established
  - provide a mix of structure types and elements
  - consider both high and low traffic volumes

Background

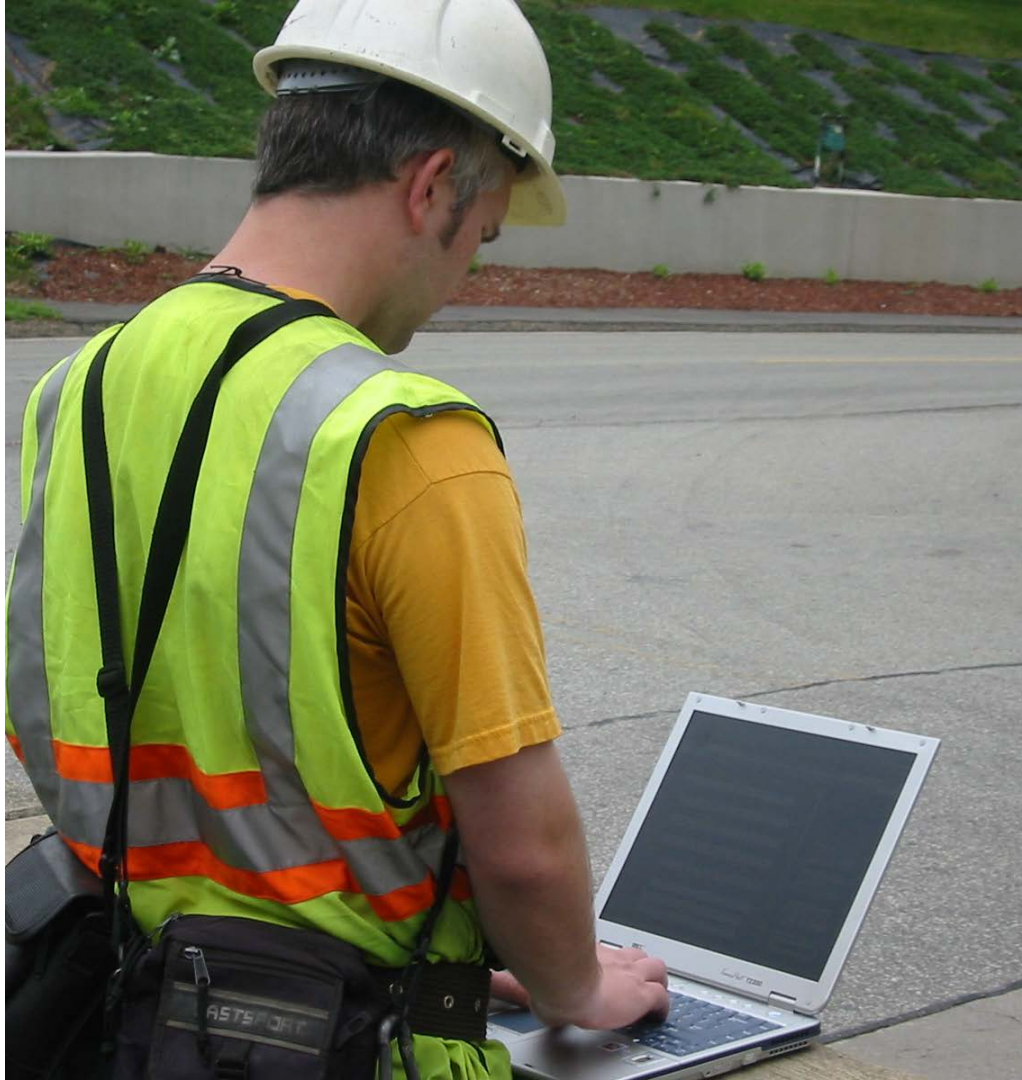
- The requirement for highway bridge owners to address bridges with fracture critical members is established in the National Bridge Inspection Standards (NBIS):
  - 23 CFR 650.313 (e) requires that owners
    - “Identify bridges with FCMs…”
  - 23 CFR 650.313 (e) (1) further specifies
    - “Bridges with fracture critical members. In the inspection records, identify the location of FCMs and describe the FCM inspection frequency and procedures. Inspect FCMs according to these procedures.”

Background

- NBIS references continued:
  - 23 CFR 650.315 (b) relating to the Inventory
    - “For…fracture critical member…inspections enter the SI&A data into the State or Federal agency inventory within 90 days of the date of inspection for State or Federal agency bridges and within 180 days of the date of inspection for all other bridges.”
  - 23 CFR 650.305 provide Definitions
    - “Fracture critical member (FCM). A steel member in tension, or with a tension element, whose failure would probably cause a portion of or the entire bridge to collapse. “
    - Fracture critical member inspection. A hands-on inspection of a fracture critical member or member components that may include visual and other nondestructive evaluation.”

Objectives

- Developed at the request of the FHWA:
  - Document the current state of the practice
  - Assess whether there are areas in the management of fracture critical bridges that warrant a change in national policy or focus
  - Identify any gaps in inspection, reporting or practices
- An independent review of the quality and sufficiency of the safety inspection practices of bridges with fracture critical members



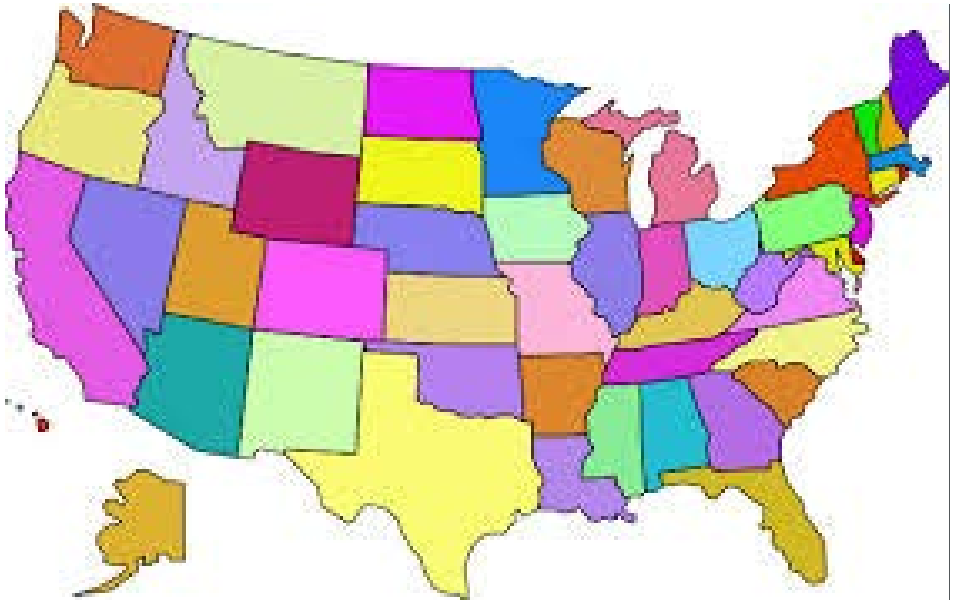
02 Introduction

Introduction

- Bridge inspection information for 94 Bridges solicited from 34 States
  - Reviewed from May-August, 2012 to assess the effective management of fracture critical bridges
- HDR tasked to review bridge inspection information and gain a better understanding of how this important area of the bridge program is administered.

Introduction

- States solicited by the FHWA Office of Bridge Technology
  - “To provide the most recent copies of the fracture critical inspection report, any information you can provide to help us understand the fracture critical inspection process for the structure, information about critical findings and follow-up actions specific to fracture critical inspection of the bridge, and the biennial inspection report.”



03 Findings

Typical FCM Findings

- Areas of Good Practice:
  - Agency-issued documentation specifically dealing with FCM inspection procedures and processes;
  - Tables listing all FCMs and/or Fatigue Prone Details (FPDs);
  - Inspection plans detailing access methods, traffic control requirements and inspection procedures;
  - Sketches and photos of FCMs and/or FPDs; and
  - Chronological listing of dates from field inspection to processing of bridge inspection data.

Common Areas of Good Practice

Findings 1 through 5

Common Areas of Good Practice

- **Finding No. 1** – Agency-issued documentation specifically dealing with FCM inspection procedures and processes:
  - Most of the States have developed and communicate policy, definitions, descriptions and tracking procedures for the safe management of bridges with FCMs.
  - Some describe the fracture critical components in narrative form and locate each of them on sketches of floor systems, elevations and/or cross-sections.
  - Many specify the inspection frequencies of FCMs.

Results:

74/94 or 79% of the bridges reviewed had Agency-issued documentation specifically dealing with FCM inspection procedures and processes.

Example of FCM Inspection Procedures and Processes

Subsection X.X.1 Purpose

Fracture Critical Inspections are regularly scheduled inspections to examine the fracture critical members (FCM) or member components of a bridge. FCMs are steel tension members or steel tension components of members the failure of which would likely result in a bridge collapse. FCMs require more thorough and detailed inspections than the members of non-fracture critical bridges. In recognition of this, Federal Regulation 23 CFR 650.303(e)(1) requires all states to establish Fracture Critical Bridge Inspection procedures.

Example of FCM Inspection Procedures and Processes

Subsection X.X.2 Precision

A Fracture Critical Inspection is a hands-on inspection. Hands-on means a visual/manual inspection made at a distance no greater than arm's length from the entire member/member component surface. Every square foot of the member/member component is examined. The observations and/or measurements are used to determine the structural capacity of the member/member component, to identify any changes from previous Fracture Critical Inspections, and to ensure that the structure continues to satisfy present safety and service requirements. Under-bridge access equipment is typically required to move the inspector within arms length of the critical members. There may be permanent work platforms and walkways available on some larger structures to aid in inspection work.

Example of FCM Insp. Procedures, Processes & Sketch

FRACTURE CRITICAL INSPECTION REPORT

FRACTURE CRITICAL BRIDGE

INSPECTION SUMMARY SHEET

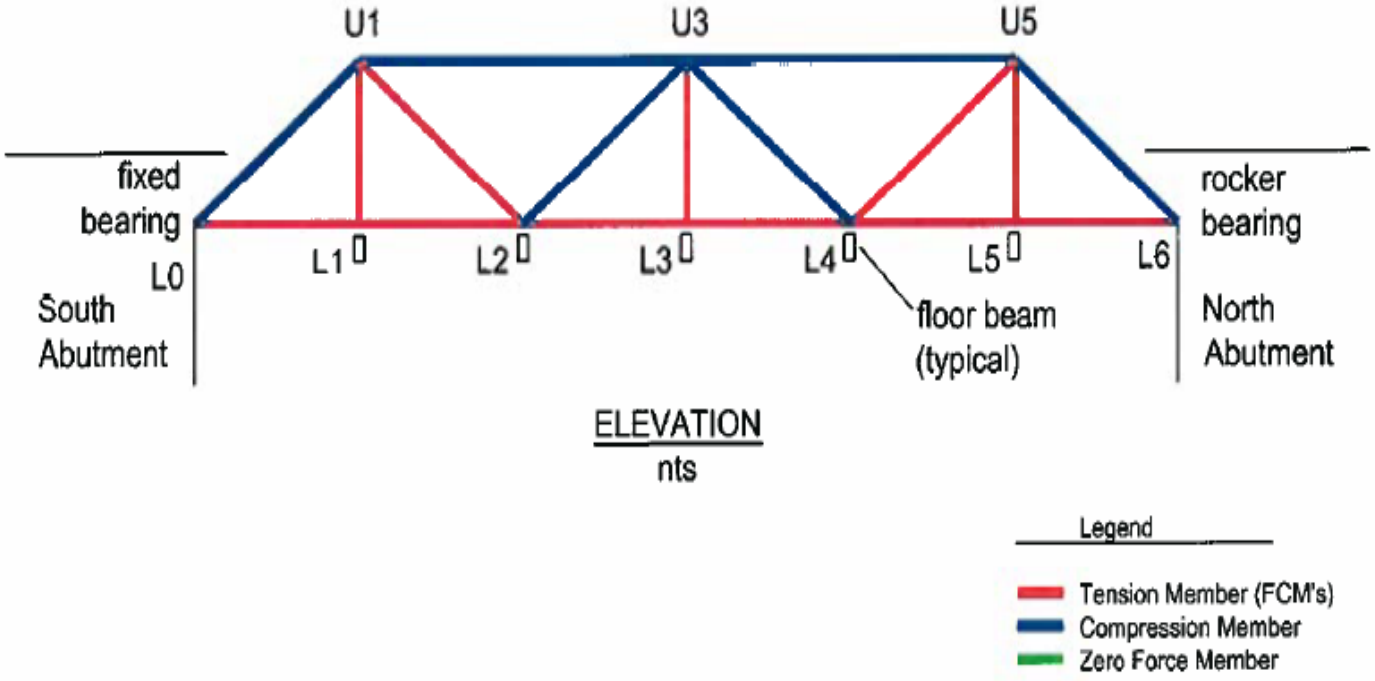
Features to be inspected: Truss Tension Member (Riveted)

Procedures:

1 As required, use mirrors or other equipment to check inside surfaces of FCMs.
2 Check for loose or unevenly loaded member sub-elements
3 Check all rivets at connection plates, with emphasis on first row. The first row is the row closest to the edge of the connection or gusset plate.
4 Check for any welds, including plug, tack, or repair welds and note any cracks.
5 Check FC members and associated connection or gusset plates for areas of heavy or pitted corrosion, nicks, gouges, sharp bends, and collision damage. Record location of all these conditions and estimated section loss, if applicable.
6 Check all heat straightened or repaired areas. Record location of these areas, regardless of condition.

FCM Location	FCM Type	FCM Per Girder or Truss Line
Span 1	Truss Tension Member (Riveted)	67

Example of FCM Insp. Procedures, Processes & Sketch



Example of FCM Inspection Procedures and Processes

Subsection X.X.3 Fracture Critical Inspection Frequency

Visual/hands-on Fracture Critical Inspections are required at regular intervals not to exceed 24 months (more frequently is acceptable). When members/member components are determined to be deficient and in need of more frequent inspections, the Inspection Program Manager may recommend more frequent Fracture Critical Inspections at his/her discretion. A Fracture Critical Inspection is a supplemental inspection to the Routine Inspection.

Maximum Inspection Interval:

- Hands-on/Visual ..... 24 months
- Nondestructive Testing (NDT) ..... 72 months (fatigue)

Included in the nondestructive testing are pin and hangers; live load bearing anchor pins and link bars; Category D, E, and E' details; special details such as out-of-plane bending; intersecting welds; and butt welds. This applies to bridges with an ADT greater than 50,000.

- Nondestructive Testing (NDT) ..... 48 months (condition)

Inspection on a 48-month interval is recommended when the superstructure has NBI rating of 4 or less.

Common Areas of Good Practice

- **Finding No. 2** – Tables listing all FCMs and/or FPDs:
  - Several of the States incorporate tables listing all FCMs and/or FPDs by span and/or truss line (if applicable), which can be used to organize the critical components to be evaluated during the field inspection and to ensure that each FCM and/or FPD is inspected, similar to using a checklist.

Results:

19/94 or 20% of the bridges reviewed had tables listing all FCMs and/or FPDs.

Example of Table Listing all FCMs and FPDs

FRACTURE CRITICAL DATA

FRACTURE CRITICAL/FATIGUE SENSITIVE ELEMENTS: Main Girder 3-1 and 3-2
CONSTRUCTION: Built-up plate girder using welded construction

NOTE: Only the inside face of the lower portion of the web and top inside face of the bottom flange are visible for inspection. The remaining portions of the main girders are encased by concrete.

DETAIL DESCRIPTION AND LOCATION	FATIGUE CATEGORY	TYPE CONNECTION	TYPE WELD	COMMENTS
Main Girder (A1)	B	N/A	N/A	Web and flanges of built-up plate girders
Floor Beam to Main Girder (A2)	B	Welded	Full Penetration	Floor Beam is bolted to stiffener which is welded to Main Girder
Cross Girder to Main Girder (A3)	B	Bolted	N/A	Cross Girder is welded to plate which is bolted to Main Girder
Bottom Flange to Web Connection (A4)	B	Welded	Continuous Fillet	
Bottom flange splice (A5)	B	Welded	Groove Weld	

Example of Table Listing all FCMs and FPDs

FRACTURE CRITICAL/FATIGUE SENSITIVE ELEMENTS: Cross Girder at End Pier 4
CONSTRUCTION: Built-up plate girder using welded construction

DETAIL DESCRIPTION AND LOCATION	FATIGUE CATEGORY	TYPE CONNECTION	TYPE WELD	COMMENTS
Cross Girder (B1)	B	N/A	N/A	Web and flanges of built-up plate girders
Main Girder to Cross Girder Connection (B2)	C	Welded	Continuous Fillet	Main Girder is bolted to stiffener which is welded to Cross Girder
Main Girder extension to Cross Girder connection (B3)	C	Welded	Continuous Fillet	Only applies to east face of Cross Girder
Bearing plate connection to bottom flange (B4)	C	Welded	Continuous Fillet	
Flanges to web connections (B5)	B	Welded	Continuous Fillet	

Common Areas of Good Practice

- **Finding No. 3** – Inspection plans detailing access methods, traffic control requirements and inspection procedures:
  - Many of the States provide bridge-specific inspection plans detailing access methods, traffic control requirements and inspection procedures recommended to be followed by subsequent inspection or maintenance forces to ensure that each FCM and/or FPD is afforded a “hands-on” inspection, meeting the NBIS requirements to place the inspector within arm’s reach.

Results:

55/94 or 59% of the bridges reviewed had inspection plans detailing access methods, traffic control requirements and inspection procedures.

Example of Inspection Plans Detailing Access Methods, Traffic Control Requirements & Inspection Procedures

INSPECTION PROCEDURE:

The structure was inspected using an Under Bridge Inspection Unit (UBIU) with a 60 foot horizontal reach, except in Spans 1, 2, and 18, which were accessed by a bucket truck with a 35 foot vertical reach. Right lane closures according to Publication 213 Figure PATA 18 were implemented. Due to the roadway width, UBIU should be deployed from the right lane in both directions, and the inspector will have full bridge access.

Common Areas of Good Practice

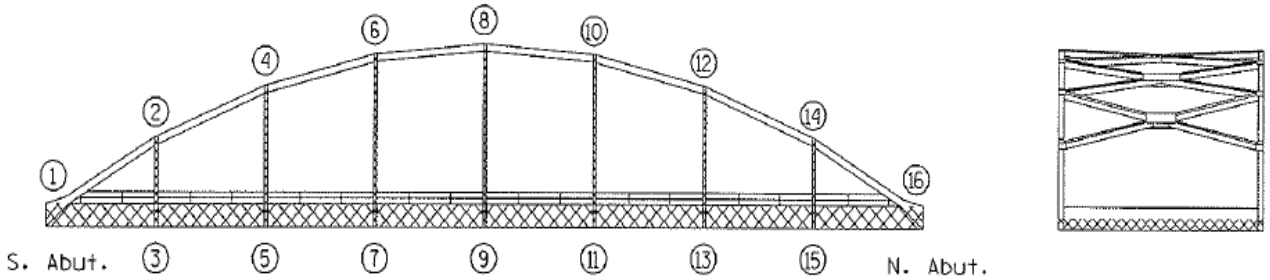
- **Finding No. 4** – Sketches and photos of FCMs and/or FPDs:
  - Many of the States require bridge-specific sketches and photos of FCMs and/or FPDs, which ensures that each FCM and/or FPD is documented with current conditions on the date(s) inspected.
  - This also provides a visual/quantitative history of the condition of the critical components, which can indicate the rate of deterioration and aid in determining the remaining years of useful life of each critical component.

Results:

42/94 or 45% of the bridges reviewed had sketches and photos of FCMs and/or FPDs.

Example Sketch of FCMs and FPDs

Elevation Schematic

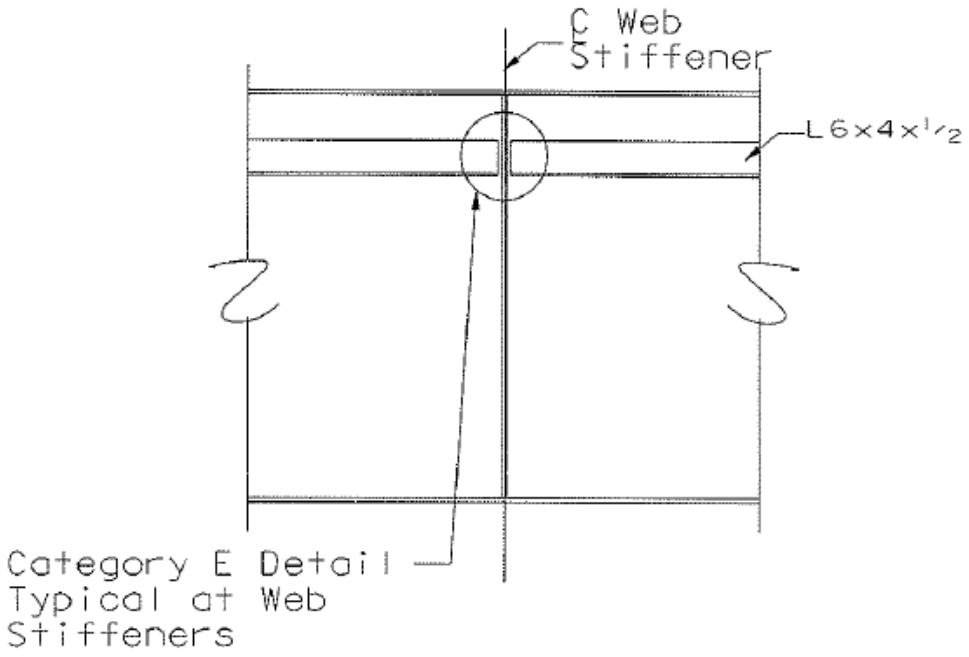


=Fracture Critical Members

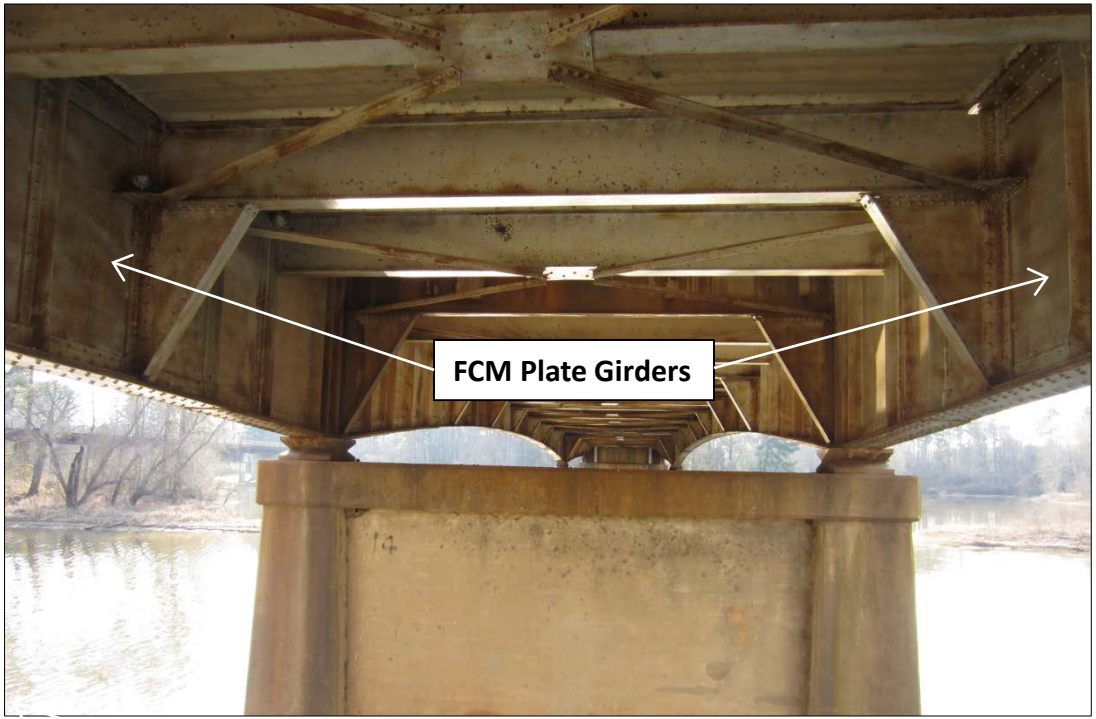
○ Panel Point Number (PPT)

Example Sketch of FCMs and FPDs

Web Stiffener Schematic



Example Photo of FCMs and FPDs



Common Areas of Good Practice

- **Finding No. 5** – Chronological listing of dates from field inspection to processing of bridge inspection data:
  - Several of the States mandate including a chronological listing of dates from field inspection to processing of bridge inspection data.
  - This directive ensures the timely reporting of FCM details via the entry of bridge inspection data within the time allotted in the NBIS
    - 90 days for on-system bridges
    - 180-days for off-system bridges

Results:

29/94 or 31% of the bridges reviewed had a chronological listing of dates from field inspection to processing of bridge inspection data.

Example of Chronological Listings of Dates from Field Inspection to Processing of Bridge Inspection Data

Inspection Submission Status:

Submitted to QC Engineer on: 10/15/2010
QC Submission Number: R0101201

QC Review Completed: 10/15/2010
QC Engineer:

Submitted to Liaison Engineer on: 10/15/2010
Liaison Submission Number: 01035

Liaison Review Completed: 10/18/2010
Liaison Engineer:

Submitted for BIIS Processing on: 10/18/2010
BIIS Submission Number: .kp1

Current Status: Keypunched, Sent to BIIS
Check Value: 1,759,140,257

Typical FCM Findings

- Improvement Opportunities include:
  - Better documentation verifying that bridge inspection data from the FCM inspections are entered within the allotted time per the NBIS;
  - Better use of sketches to properly label the identity and location of FCMs;
  - Better use of photos to adequately identify FCMs and their level of deterioration; and
  - More detailed location and category information on FPDs associated with the FCMs as part of the procedures for inspecting each FCM.

Common Areas of Improvement

Findings 1 through 4

Common Areas of Improvement

- **Finding No. 1** – Lack of sketches properly identifying and locating FCMs:
  - The lack of sketches properly labeling the identity and location of FCMs, in accordance with the NBIS, makes it difficult to determine whether all of the FCMs on the bridge are being inspected.
  - Many of the bridge inspection records reviewed did not provide sketches properly labeling the identity and location of FCMs.

Results:

36/94 or 38% of the bridges reviewed lacked sketches properly identifying and locating FCMs.

Common Areas of Improvement

- **Finding No. 2** – Lack of photos adequately identifying FCMs:
  - The lack of photos adequately identifying FCMs makes it difficult to determine the condition of the FCMs on the bridge.
  - Several of the bridge inspection records reviewed did not provide photos adequately identifying FCMs.

Results:

25/94 or 27% of the bridges reviewed lacked photos adequately identifying FCMs.

Common Areas of Improvement

- **Finding No. 3** – Lack of information on fatigue prone details associated with the FCMs, as part of the procedures for inspecting each FCM:
  - The lack of information on fatigue prone details associated with the FCMs, as part of the procedures for inspecting each FCM, makes it difficult to ensure that the most critical details on the components are being evaluated.
  - More than half of the bridge inspection records reviewed did not include location and category information on fatigue prone details associated with the FCMs, as part of the procedures for inspecting each FCM.

Results:

55/94 or 59% of the bridges reviewed lacked information on fatigue prone details associated with the FCMs, as part of the procedures for inspecting each FCM.

Common Areas of Improvement

- **Finding No. 4** – Lack of documentation verifying the bridge inspection data from the FCMs are submitted in a timely manner:
  - The lack of documentation verifying that the bridge inspection data from the FCMs are entered within the allotted time, in accordance with the NBIS (90 days for on-system bridges and 180-days for off-system bridges), makes it difficult to confirm.
  - A majority of the bridge inspection records reviewed did not ensure the timely reporting of FCM details via the entry of bridge inspection data within the time allotted.

Results:

65/94 or 69% of the bridges reviewed lacked documentation verifying that the bridge inspection data from the FCMs are entered within the allotted time.

04 Conclusions

Conclusions

- The products from the independent review of 94 bridges with fracture critical members from the NBI will improve the processes used by bridge owners in the effective management of bridges with FCMs.
- Sharing **Common Areas of Good Practice** and **Common Improvement Opportunities** with other bridge owners:
  - Improve the effective management of bridges with FCMs
  - Provide information for the FHWA to better manage the bridge inspection program

Thank you for your time

QUESTIONS?