Navigating New Federal Policies on Bridge Redundancy

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Introduction

- Silver Bridge Collapse in 1967
- Development of the Fracture Control Plan in 1978:
  - Design and material requirements → AASHTO LRFD Bridge Design Specs
  - Fabrication and shop inspection → AASHTO/AWS D1.5M/D1.5 Bridge Welding Code
  - In-service inspection requirements → NBIS, AASHTO MBE
- NBIS: National Bridge Inspection Standards:
  - 23 CFR 650.C

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Introduction

- Fracture Critical Member (now Nonredundant Steel Tension Member):
  - Steel member in tension (or partially in tension) which failure results in collapse of the structure.
- Redundancy:
  - Ability to provide serviceability after the failure of a primary member.
- FCM Inspection (now NSTM Inspection):
  - Hands-on inspection to discover indication of future fracture in steel.
  - Carried-out at a default 24-month interval.
- FCM Fabrication (now NSTM Fabrication):
  - Section 12 of D1.5
  - Includes fabrication (materials and means) and shop inspection requirements.

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Where were we yesterday?

2012 FHWA Memorandum

- Clarification of Requirements for FCMs.
- Definitions:
  - Recognized inconsistencies across NBIS, MBE and LRFD.
  - FCM means that if the member fails, the bridge cannot carry traffic.
- Redundancy:
  - Load Path Redundancy. "Traditional". Three or more girder/truss lines.
  - Structural Redundancy. "3-dimensional mechanism", "Alternative". Requires FEA.
  - Internal Member Redundancy. In fastened (riveted/bolted) built-up members.

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Where were we yesterday?

2012 FHWA Memorandum

- Identification of FCMs:
  - For design/fabrication:
    - If it is not load path redundant meet CVN req's in LRFD and Sec. 12 of D1.5.
  - For in-service inspection:
    - Can take advantage of refined analysis, i.e. structural redundancy.
    - FCM not meeting the FCP remain FCM.
    - Cannot take advantage of internal redundancy.

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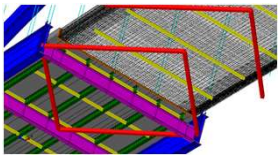
Where were we yesterday?

2012 FHWA Memorandum

- Analytical requirements for redundancy
  - TBD:
    - Dynamic effects
    - Load cases
    - 3-D system behavior
- System Redundant Members (SRM)
  - Not load-path redundant
  - Redundancy shown through analysis
  - No FCM inspection
  - Still need FCP fabrication



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Slide 2

CJ0 Overall use this guidance for bullet point punctuation: If the bullet point contains a sentence, you should add a period to the end of it. If not a full sentence, delete periods.
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CJ1 Overall use this guidance for capitalization in bullet points: Only capitalize first word and proper nouns
Covelli, Julia, 2023-09-13T20:06:24.793

CJ2 Overall use this guidance on acronyms: In first instance, spell out, then use acronym thereafter. I.e. first use: Federal Aviation Administration (FAA) and then FAA thereafter
Covelli, Julia, 2023-09-13T20:12:43.694

Slide 4

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Covelli, Julia, 2023-09-13T20:13:28.826

Where are we today?

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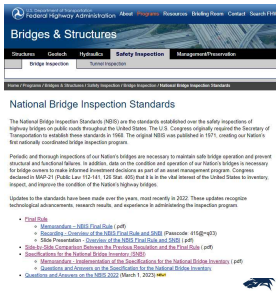
2022 FHWA Memorandum and NBIS

- New memo issued on May 9 2022.
- Major update to the NBIS published on May 6, 2022:
  - Number of changes affecting routine inspection and other inspection types.
  - Focus on FCM inspection requirements.
- States may develop a policy to alleviate FCM inspection.
- If SRMs were in your inventory, update procedures by June 6, 2024.



Where are we today?

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2022 FHWA Memorandum and NBIS

- Changes to the NBIS regarding FCMs:
  - FCM is "obsolete", new term is Nonredundant Steel Tension Member (NSTM)
    - Primary steel member fully or partially in tension, and without redundancy, whose failure may cause a portion or the entire bridge to collapse.
    - NSTM replaces FCM everywhere (FCM inspection → NSTM inspection)
    - Will be adopted by AASHTO and AWS in the next specs.
  - Other new definitions:
    - Internal redundancy: Within cross-section, fracture does not propagate among components.
    - Load path redundancy: Based on number of primary members (3+).
    - System redundancy: Within the system, full fracture of a member does not result in collapse.

Where are we today?

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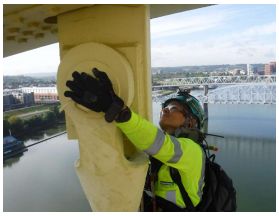
2022 FHWA Memorandum and NBIS

- NSTM inspection intervals:
  - Method 1:
    - 24 months is the standard.
    - 12 months is for condition 4 (poor) or worse.
    - NEW OPTIONAL 48 months for:
      - Built after 1978 and per the FCP
      - Infinite fatigue life
      - No cracking history
      - Condition 6 or better
      - Design load inv. RF ≥ 1.0.
      - No posting for routine permits
      - No pin and hangers
  - Method 2: "Rigorous assessment"



Where are we today?

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2022 FHWA Memorandum and NBIS

- Where do I get alleviation from NSTM inspection?
  - § 650.313 (f) (1) (i)
- … may choose to demonstrate a member has system or internal redundancy such that it is not considered an NSTM. The entity may develop and submit a formal request for FHWA approval of procedures using a nationally recognized method to determine that a member has system or internal redundancy. FHWA will review the procedures for approval based upon conformance with the nationally recognized method.

Where are we today?

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2022 FHWA Memorandum and NBIS

- What does the request for policy approval need:
  - A. Written policy and procedures
  - B. Identification of nationally recognized methods
  - C. Baseline condition of bridges
  - D. Description of what affect system or internal redundancy
  - E. Routine inspection requirements
  - F. Special inspection requirements
  - G. Evaluation criteria for review

Where are we today?

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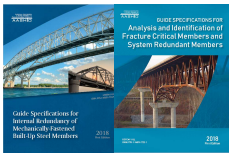
2022 FHWA Memorandum and NBIS

- Nationally recognized methods of analysis:
  - Consult Office of Bridges and Structures, currently:
    - AASHTO Guide Specs. for Analysis and Identification of FCMs and SRMs.
    - AASHTO Guide Specs. for Internal Redundancy of Mechanically-Fastened Built-Up Steel Members.
    - Other methods endorsed by a national organization (2+ states) or adopted by two or more States or by the Federal government are acceptable.
  - Factors affecting applicability to be addressed in the procedure.
  - For journal-published include editorial practice, board, impact.



Where are we today?

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2022 FHWA Memorandum and NBIS

- Baseline condition of the bridge:
  - Fatigue cracks
  - Fatigue life considerations
  - Severity and extent of corrosion
  - Impact damage

Where are we today?

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2022 FHWA Memorandum and NBIS

- Details that affect redundancy:
  - System redundancy:
    - Pin and hangers
    - Nonredundant eyebars
    - Plug welds
    - Discontinuous back-up bar splices
    - CIF
    - Other fracture prone details.

Where are we today?

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2022 FHWA Memorandum and NBIS

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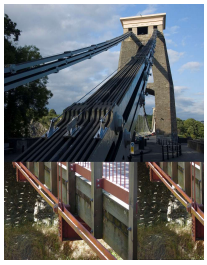

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2022 FHWA Memorandum and NBIS

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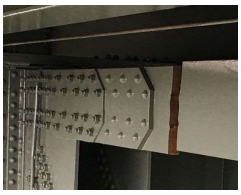

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2022 FHWA Memorandum and NBIS

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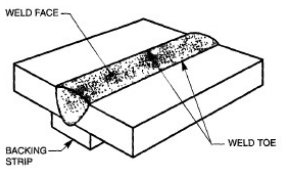

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2022 FHWA Memorandum and NBIS

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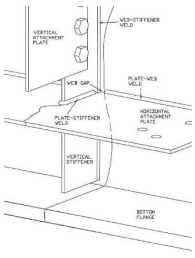

Where are we today?

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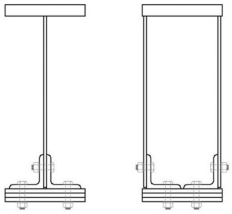
- Details that affect redundancy:
  - Internal redundancy:
    - Section proportions and connections
    - Ability to identify faulted member
    - Strength in the faulted state
    - Serviceability in the faulted state



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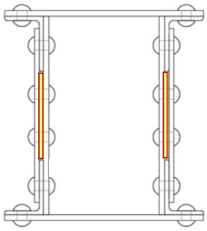

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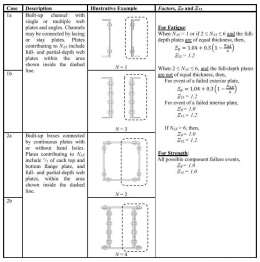

Case	Description	Illustrative Example	Factors, Z_F and Z_{FI}
1a	Built-up channel with single or multiple web plates and angles. Channels may be connected by bracing or cross-frames. Plates contributing to N_{cr} include full- and partial-depth web plates within the area shown inside the dashed box.	$N_{cr}=1$	**For Fatigue:** When $N_{cr}=1$ or if $2 \le N_{cr} < 6$ and the full-depth plates are of equal thickness, then, $Z_F = 1.04 + 0.3\left(1 - \frac{t_{wp}}{t_w}\right)$, $Z_{FI} = 1.2$. When $2 \le N_{cr} < 6$ and the full-depth plates are not of equal thickness, then, For event of a failed exterior plate, $Z_F = 1.04 + 0.3\left(1 - \frac{2t_{wp}}{t_w}\right)$, $Z_{FI} = 1.2$. For event of a failed interior plate, $Z_F = 1.8$, $Z_{FI} = 1.2$. If $N_{cr} > 6$, then, $Z_F = 1.8$, $Z_{FI} = 1.2$. **For Strength:** All possible component failure events, $Z_F = 1.0$, $Z_{FI} = 1.0$.
1b		$N_{cr}=3$	
2a	Built-up boxes connected by continuous plates with or without hand holes. Plates contributing to N_{cr} include ½ of each top and bottom flange plate, and all full-depth web plates, within the area shown inside the dashed box.	$N_{cr}=2$	
2b		$N_{cr}=4$	

Where are we today?

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- Routine inspection considerations:
  - Inspection interval
  - Access methods
  - Focus areas/conditions
- Special inspection considerations:
  - Interior members and connections
  - Inspection interval for IRMs

Where are we today?

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2022 FHWA Memorandum and NBIS

- Routine inspection considerations:
  - Inspection interval
  - Access methods
  - Focus areas/conditions
- Special inspection considerations:
  - Interior members and connections
  - Inspection interval for IRMs

Table 3.1-1—Maximum Interval between Special Inspections for Case I Members

Calculated Estimated Remaining Minimum Fatigue Life, N_f (Years)	Maximum Permitted Interval (Years)
$N_f < 20$	Larger of 2 years or $0.5N_f$*
$N_f \ge 20$	10

*The calculated inspection interval may be rounded up to the next even-year interval.

Table 3.1-2—Maximum Interval between Special Inspections for Case II Members

Calculated Estimated Remaining Minimum Fatigue Life, N_f (Years)	Maximum Permitted Interval (Years)
$N_f \le 5$	Smaller of 2 years or $0.5N_f$*
$5 < N_f < 20$	$0.5N_f$**
$N_f \ge 20$	10

*The calculated inspection interval may be rounded up to the next half-year interval.
**The calculated inspection interval may be rounded up to the next even-year interval.

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2022 FHWA Memorandum and NBIS

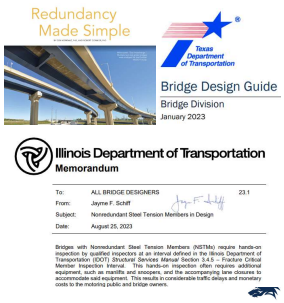
- Criteria for redundancy re-evaluation:
  - Defects, section loss
  - Impact, fire damage
  - Repair, retrofits, rehabilitations

Incentives

- Cost:
  - NSTM are recurrent large expenses over the life of a steel bridge.
- Safety:
  - Safety of inspectors.
  - Safety of drivers.
- Efficiency and effectiveness:
  - NSTM inspection is difficult and might not be effective in fracture prevention.
- Ownership:
  - Don't you want to know what components are actually critical?

Incentives

- DOTs are already applying redundancy analysis to avoid NSTM inspection:
  - WisDOT has already declassified several (over 70 spans) twin tub girder bridges.
  - IDOT has released a memo for designers and is working on revised policy.
  - TxDOT has developed policies for twin tub girders and straddle bents.



Summary and Conclusions

- FCMs are now NSTMs.
- NSTMs can now be inspected at 48 months (optional).
- NBIS and FHWA recognize both internal and system redundancy.
  - You can use it to alleviate NSTM inspection requirements.
  - Still have to fabricate per Sec. 12 of the Bridge Welding Code.
- To designate SRMs and IRMs, DOTs need to submit policy to FHWA:
  - Analysis based on nationally recognized method
  - Baseline condition and criteria for re-evaluation of redundancy
  - Details that affect redundancy
  - Routine and special inspection considerations

Questions?

Thanks for your attention

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