
Steel Bridge Deterioration Issues

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ASCE/SEI Enhancing Bridge Performance Workshop
February 21, 2008

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Acknowledgements for Source Material

Federal Highway Administration

National Steel Bridge Alliance

Robert Dexter (1956-2004)

Topics that overlap steel bridge deterioration and performance issues in

- Technologies for condition assessment;
- Concrete bridges;
- Bridge management and inspection;
- Cable supported bridges; and,
- Bridge security presentations.

Steel bridges constitute ~ 32% of NBI

~18% of steel bridges are classified as functionally obsolete

~21% are classified as structurally deficient

Common source of deficiency is age related deterioration

Steel bridge deterioration ...

Corrosion  Fatigue


Redundancy, Fracture Critical

Corrosion



Concentrated / pitting

General uniform
thickness loss



- Corrosion inspections of steel bridges inherently easier than concrete bridges
- Same corrosion related concerns as other bridge types related to concrete deck and concrete piers
 - Water penetration at deck joints, areas where concrete deck distressed
 - Corrosion, spalling, cracking, scour, etc. of concrete piers
 - Workshop discussion of concrete deck and pier elements should likely be centralized. In Concrete Bridges Committee? Any unique deck or pier issues for steel bridges?

Corrosion Protection

Must keep in mind:

- Environment
Mild, industrial, moderate, severe
- Design Detailing
Deck joints, drainage areas, debris collection

Corrosion protection systems

- Weathering steel
- Coatings/paints

Corrosion Protection Systems

Issues with Some Parts of Older Inventory

Weathering steel

- No wet-dry cycle (high rainfall, humidity, persistent fog, "tunnel-like" condition)
- Extreme marine conditions, de-icing salts, surrounding vegetation

Coatings/paints

- Inadequate surface preparation
- Poor application techniques
- Bad product

Newer Bridges and Bridges In-the-Pipe

HPS weathering steels

Active coating studies (three coat, two coat, single coat)



Simply specifying that a corrosion protection system be used is not enough



Data needs: problems with corrosion protection systems that have been identified and/or addressed

Location of problems and root source

Type of system, environment, local concern?

Repairs that have been used

Repairs that have worked. How long?

Accelerated corrosion studies vs. in-situ data

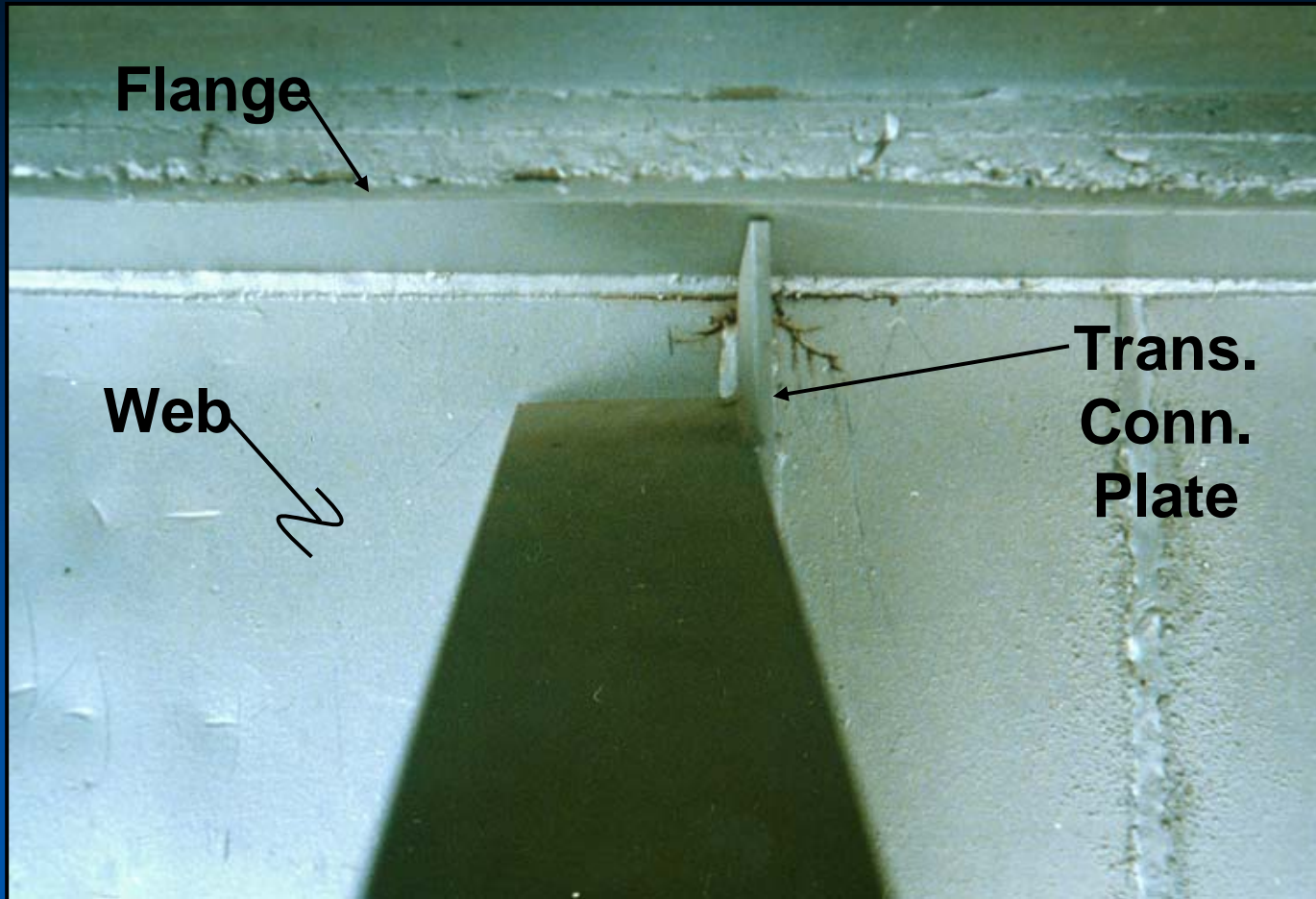


Fatigue

Reasonable Protocol for Fatigue Crack Investigation:

- Conduct remaining fatigue life analysis. If details with little/no fatigue life identified – special attention in inspection.
- Use shop drawings to help identify details susceptible to distortion-induced fatigue.
- Put attention where it is most needed.
- Flaws contribute to likelihood for problems
 - Partial penetration, lack of fusion, porosity, inclusions, undercut ...

Fatigue



Most common type of fatigue damage for U.S. bridges is **web gap cracking**

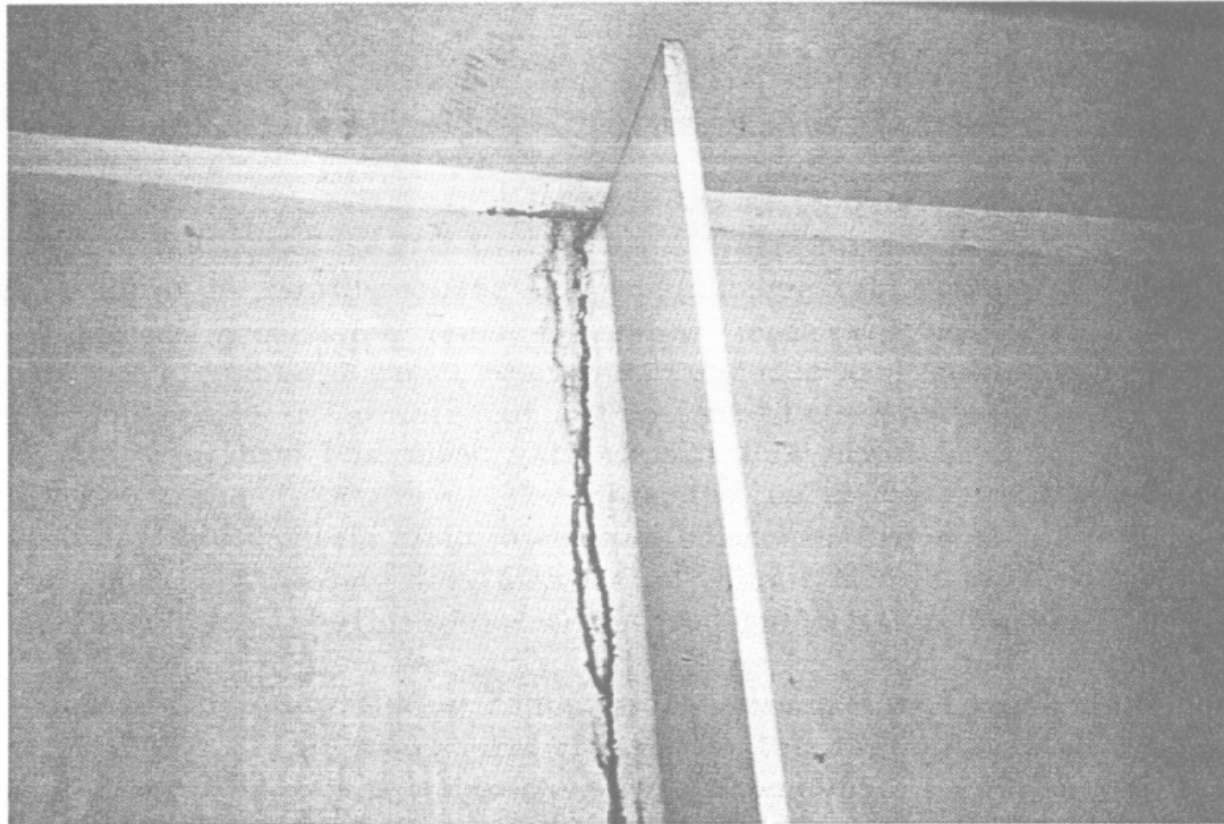
Fear of Welding to Tension Flange



Typical "milled-to-bear"
connection plate

- Only case of problems was brittle fracture of bridge in Belgium in 1950's
- Due to low quality steel used at the time
- No longer an issue (toughness requirements)

Tell-tale Signs: Bleeding at Cracks



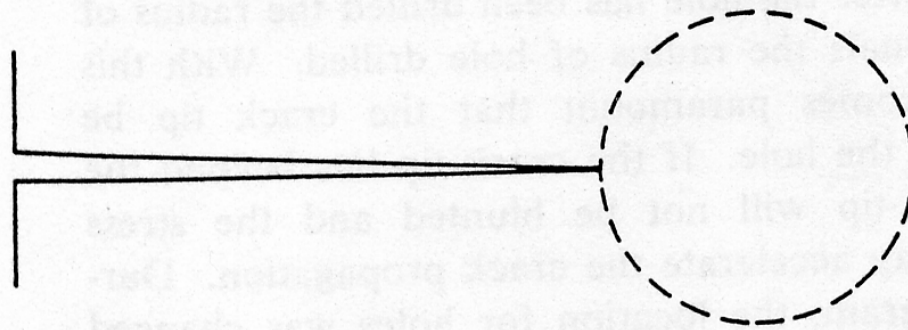
Web Gap Cracking at Bottom Flange



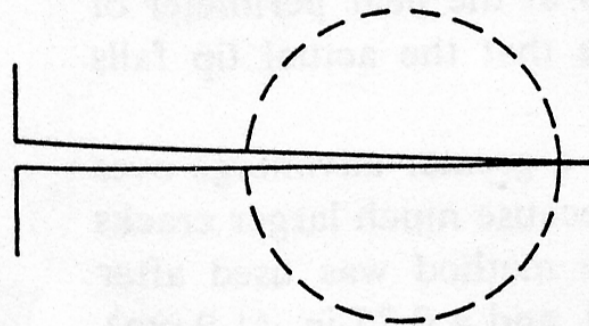
Repair and Retrofit Strategies

- Fatigue cracks are like cockroaches
 - You don't usually see just one
 - Inspection and retrofit are critical
- Repair existing cracks
 - Hole drilling
 - Doubler plates

Must Locate Crack Tip (dye-penetrant, magnetic-particle, ...)



Hole Location Finally Used To Avoid Condition Below



Severe Condition Produced By Not Encompassing
Sharp Crack Tip By Hole

Cracks Will Reinitiate at Small Holes





Bigger Cracks Require Bolted Doubler Plate





Repair and Retrofit Strategies

- Fatigue cracks are like cockroaches
 - You don't usually see just one
 - Inspection and retrofit are critical
- Repair existing cracks
 - Hole drilling
 - Doubler plates
- Retrofit other similar connections
 - Reduce driving force – cheap and effective
 - Make connection rigid – old reliable
 - Make connection more flexible – somewhat risky

Retrofit – Reduce Driving Force

Remove diaphragms

- deck distributes load
- only needed during construction
- or in service at pier for continuous spans
- future redecking?
- accidental loading?

Next best thing:
loosen bolts



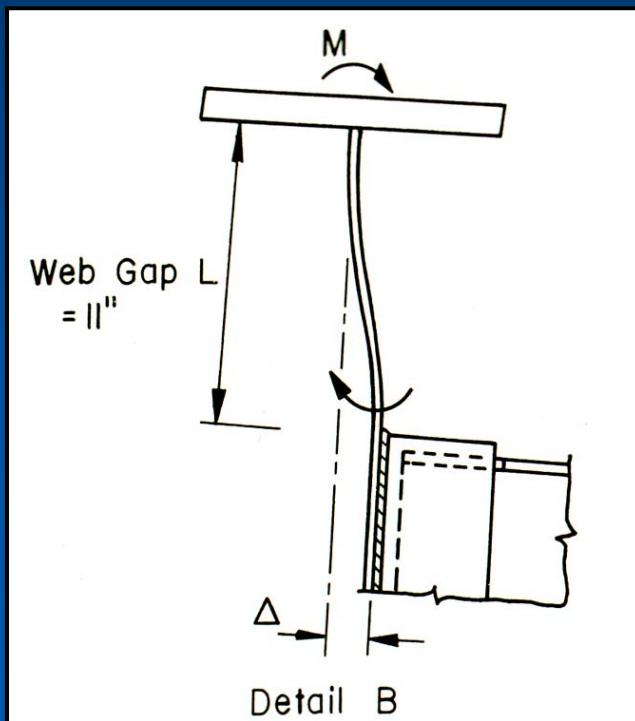
Retrofit – Make Connection Rigid

- Provide load path to flange
- May be difficult at top flange
- Rigidity of retrofit is critical



Retrofit – Make Connection More Flexible

- For deeper girders with long web gaps
- Permits out-of-plane displacement to occur over longer length or web gap (L)



Data needs: fatigue problems that have been identified and addressed

Location of problems and root source.

Local or global concern.

Repairs that have been used.

Repairs that have worked. How long?

Problems with "new" details? New steels?

Concerns with deterioration issues for steel bridges naturally leads to discussion of redundancy

- What structures are redundant and what structures aren't?
- Can redundancy be proven analytically?
- Can girder hanging from the concrete deck provide adequate redistribution of loads in twin box girder bridges?
- What structures/elements are fracture critical and what structures/elements aren't?

Very active ongoing dialogue on above issues.

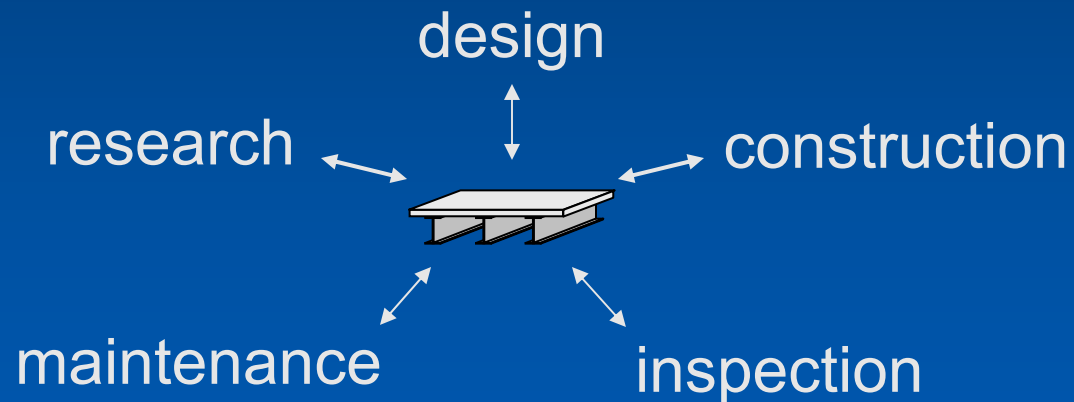
Proper assessment of urgency of deterioration concerns is directly impacted by answers to questions above.

Not:

design → construction → inspection → maintenance

research

But:



Thank You