Modern Corrosion Protection Systems Part 2:

Detailing and Service Life Considerations

Jennifer McConnell, Ph.D.

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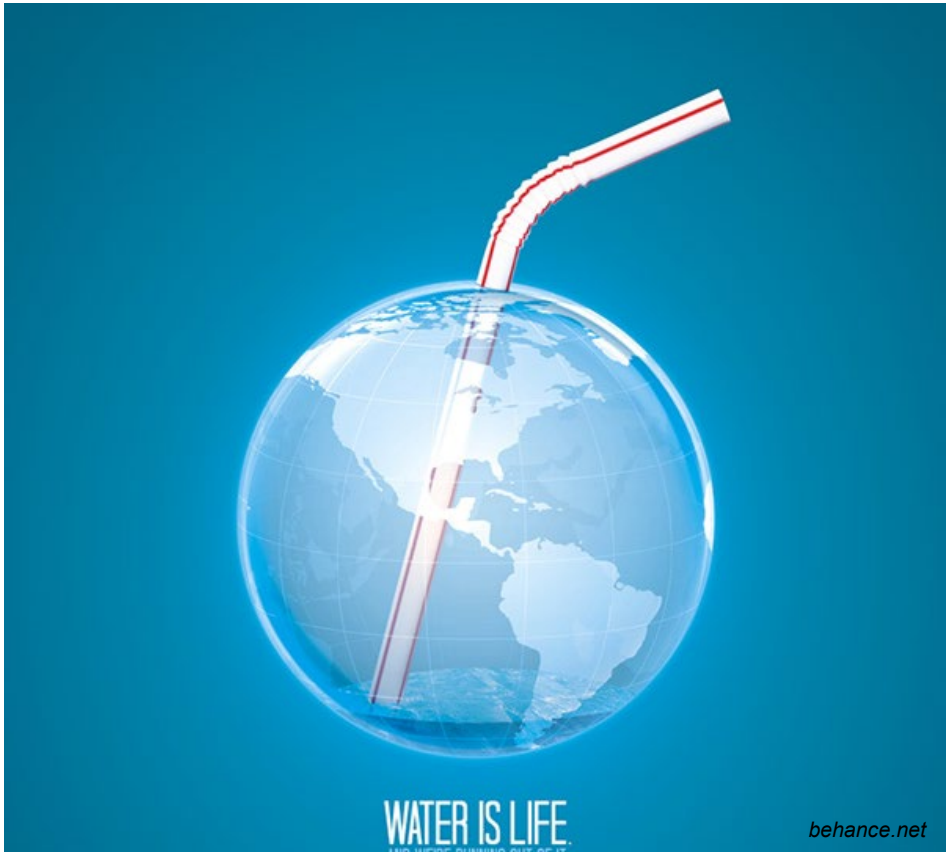
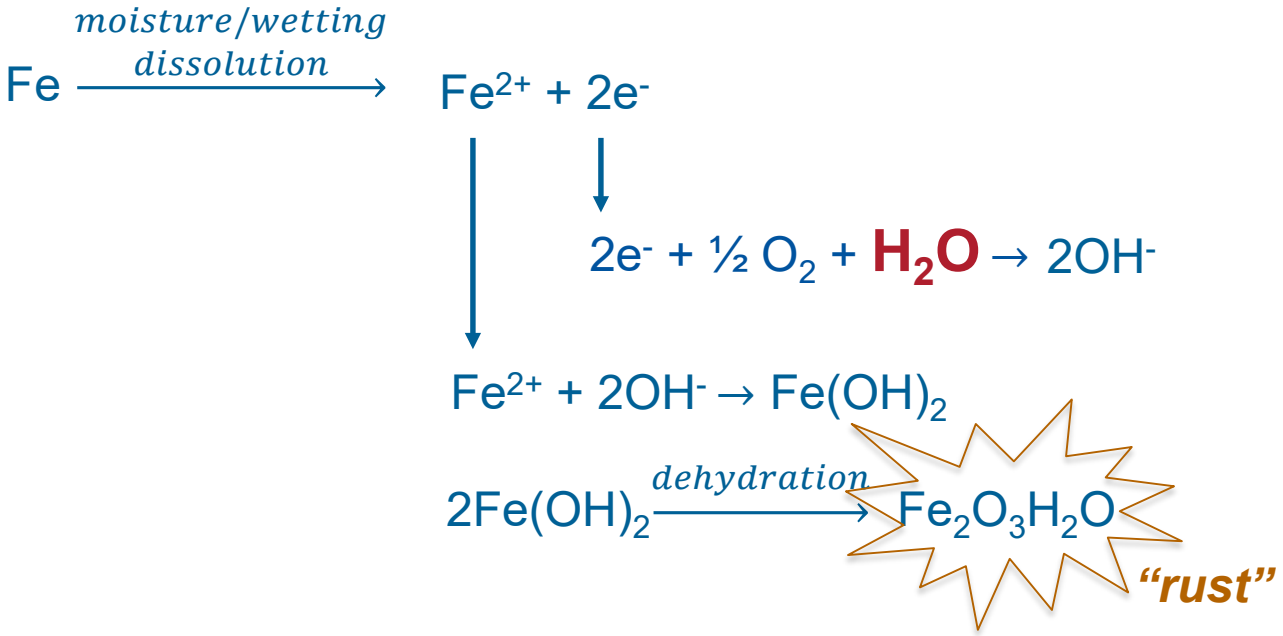
UNIVERSITY OF DELAWARE
ENGINEERING

DETAILING


runnersworld.com


WATER IS LIFE
behance.net

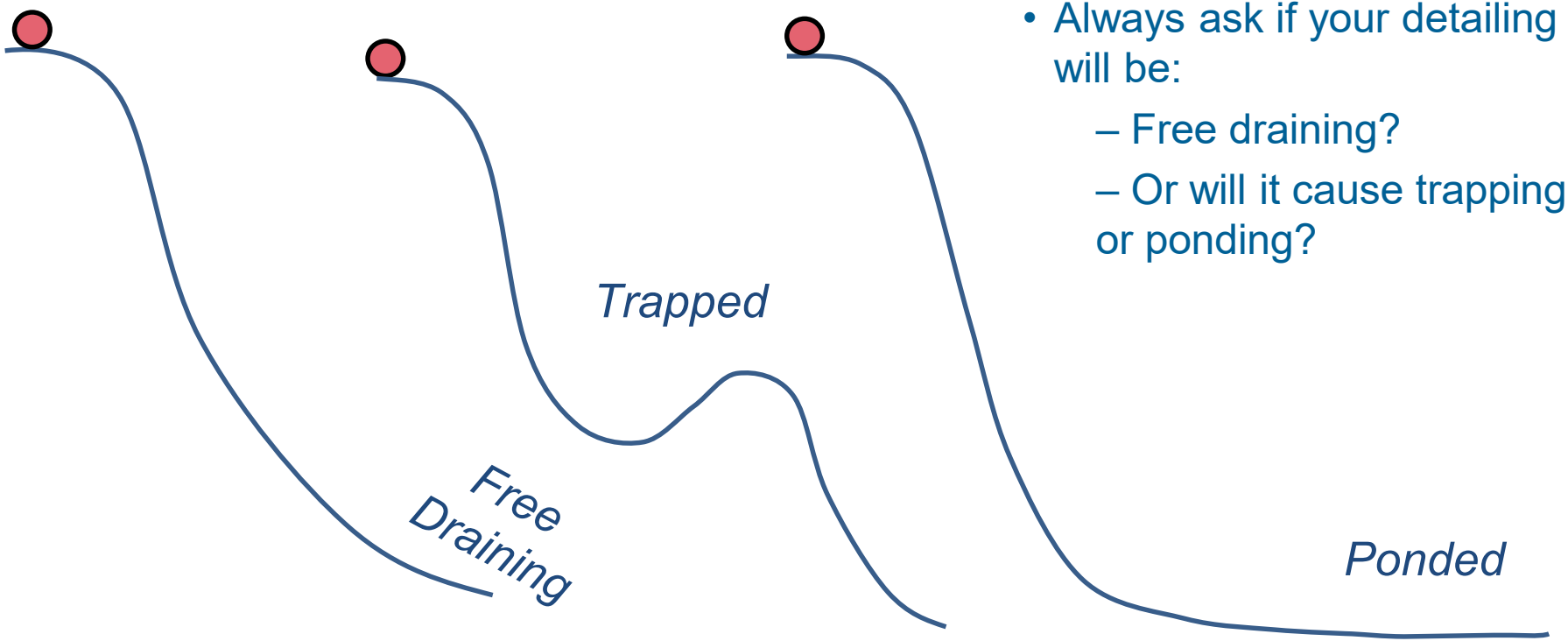
Chem101 Review:
Why is Water Bad for Steel?



Chem201 Review:
Why is Chloride Bad for Steel?

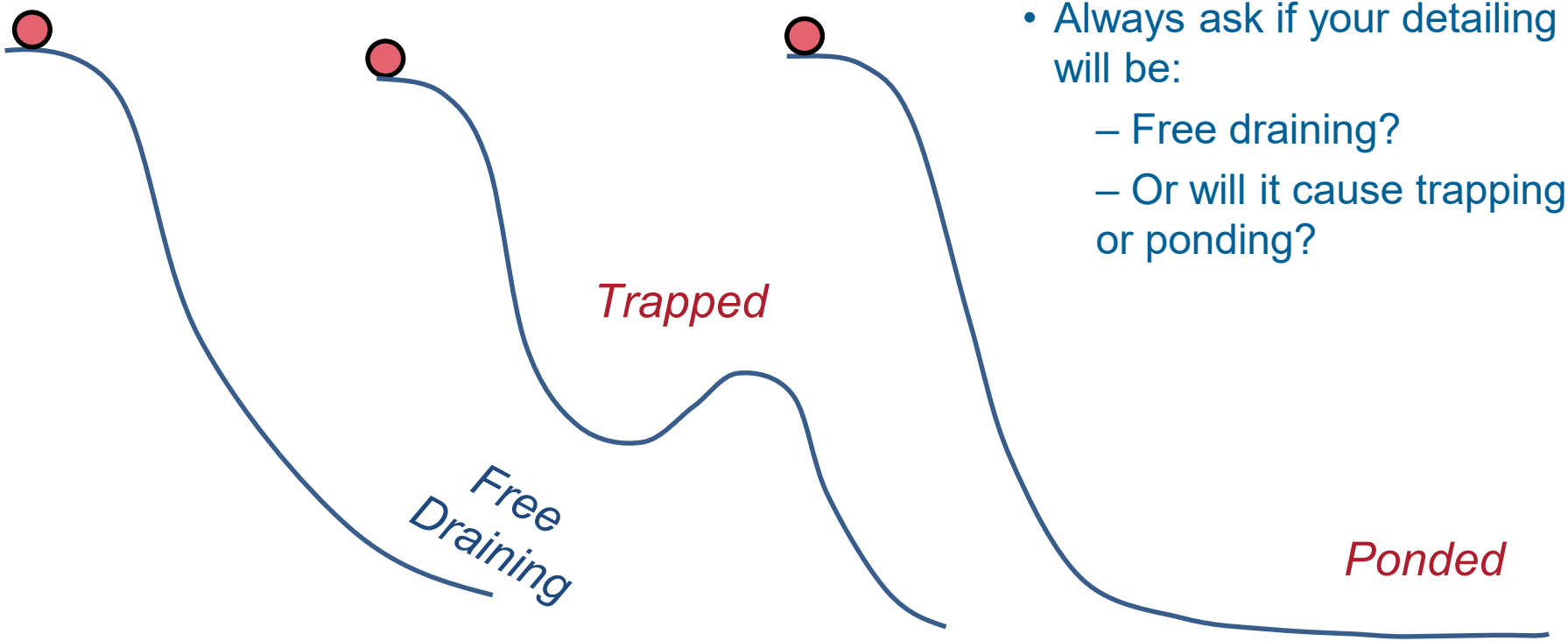
Electrochemical reaction → *Dissolved electrolytes (Cl^-) are a catalyst for the reaction*

Detailing 101 – Controlling Water



- Where does the water flow?
- Always ask if your detailing will be:
  - Free draining?
  - Or will it cause trapping or ponding?

Detailing 101 – Controlling Water



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Detailing Overview

Details that trap moisture / debris

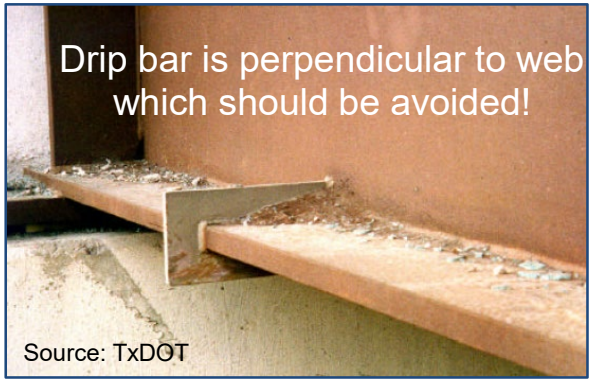
- Reentrant corners
- Cross-frame detailing
- Inclined members w/out drainage path
- Bolted connection hand holes

Exposed elements = Surfaces susceptible to ponding

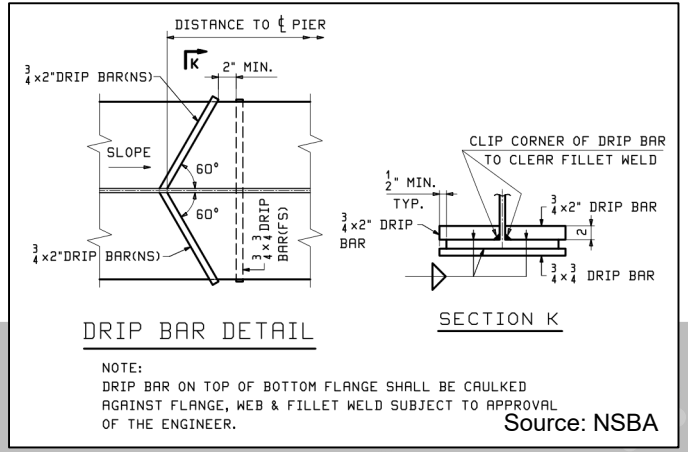
- Narrow overhangs
- Discontinuous deck materials

Trapped Debris and Moisture at Reentrant Corners

- **Detail:** Reentrant corners
- **Example**: Drip bars
- **Recommendation:** Detail at angle
- **Why:** Avoid trapped moisture and debris



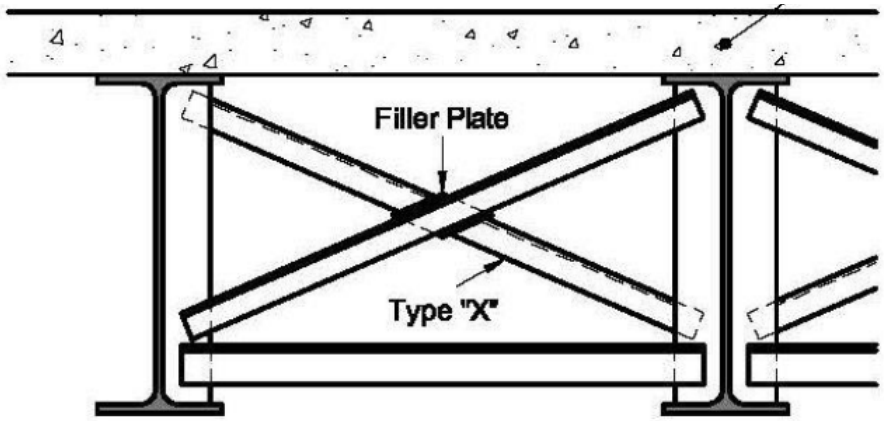
- **Detail:** Reentrant corners
- **Example**: Stiffeners
- **Recommendation:** Minimize; consider providing sufficient corner clips for drainage
- **Why:** Avoid trapped moisture and debris



Trapped Debris and Moisture on Cross-frames

Detail cross-frames "flange upwards" to reduce locations for trapped water and debris.

Provide tight fitting filler plate to eliminate gap for debris accumulation.



Source: New Zealand Weathering Steel Guide for Bridges

Source: NSBA

Trapped Moisture on Inclined Members

Provide and maintain drainage on inclined members to avoid trapped moisture and debris.

Trapped Moisture Inside of Bolted Connection Hand Holes

Connections should be designed to prevent accumulation of moisture and debris, which will lead to corrosion, while also allowing for future inspection.

Ponding and Capillary Corrosion Beneath Narrow Overhangs

Narrow overhangs contribute to ponding on exterior bottom flanges.

Capillary action causes corrosion on bottom of webs.

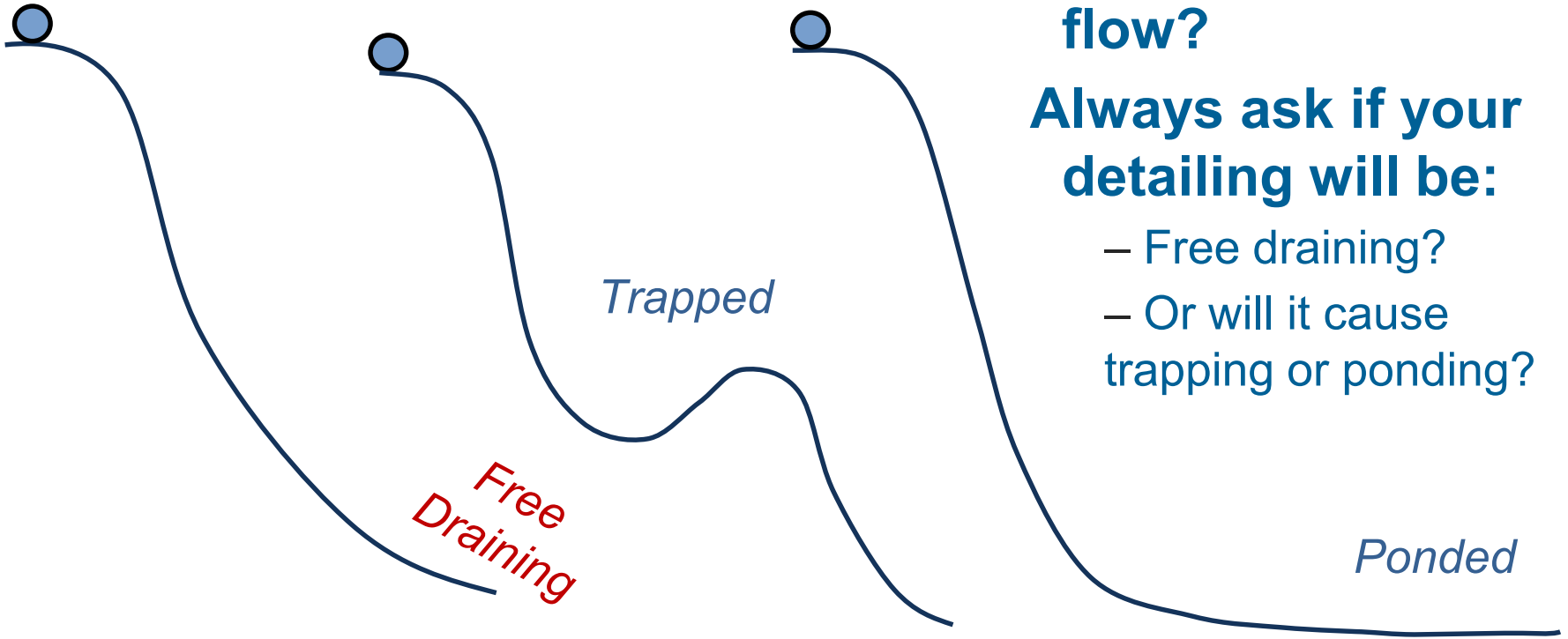
Positive Effects of Wide Overhang

Wider overhangs are recommended to provide more shelter to exterior girders.

Ponding Beneath Discontinuous Deck Materials

Discontinuous deck materials (e.g., timber and grid decks) should be avoided or have expectations of corrosion/maintenance due to constant moisture.

Detailing 101 – Controlling Water



Where does the water flow?

Always ask if your detailing will be:

- Free draining?
- Or will it cause trapping or ponding?

Leaking Joints!

Leaking joints are a ubiquitous problem, causing localized corrosion because of regular exposure to water, often laden with chlorides.

Leaking Joints Data

- **Findings from review of 70 inspection reports:**
  - One-third of bridges reviewed had worse performance below deck joints than in the remainder of the structure
  - Different agencies have different results
  - This problem affects coastal bridges and those exposed to deicing agents, and perhaps others

Agency	Number of Bridges Evaluated	Number of UWS Bridges with Worse Performance Below Joint
Deicing 1	20	12
Deicing 2	21	6
Coastal 1	12	5
Coastal 2	17	0
Sum	**70**	**23**

Leaking Joints!
Partial Solution: Painted/Coated Girder Ends

Painting the ends of UWS girders is recommended to account for possible future leaking joints.

Notes:

Painted length = 1.5 * Girder depth is typical recommendation

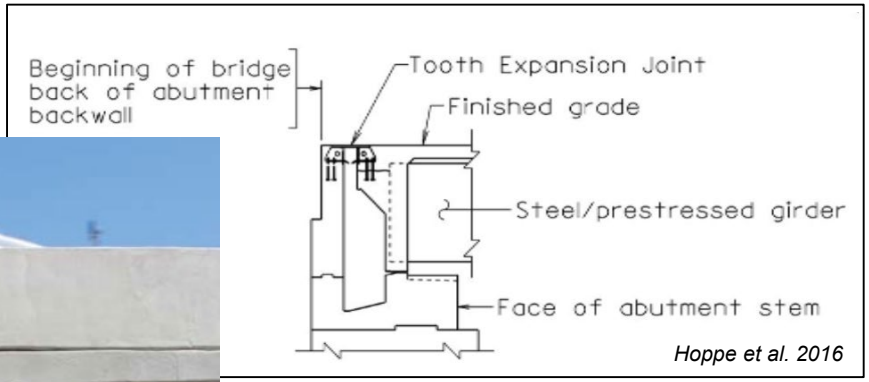
Generally use color similar to UWS

Better Solution: Eliminate Joints Where Possible
Option 1: Integral (or Semi-Integral) Abutment

Integral abutments eliminate deck joints and associated corrosion problems.

Better Solution: Eliminate Joints Where Possible
Option 2: Virginia Abutment

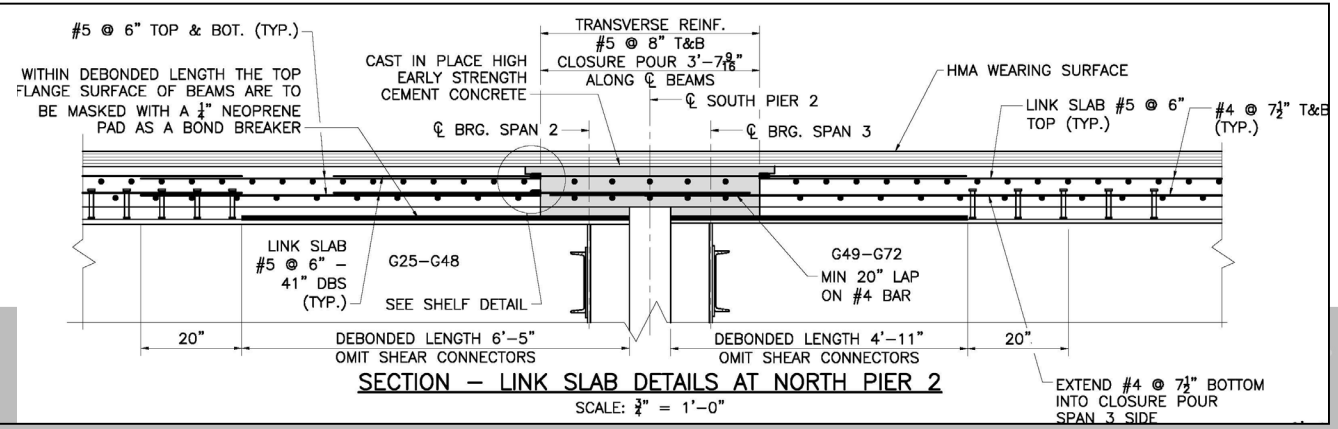
The "Virginia Abutment" provides the same corrosion benefits as integral / semi-integral abutments in situations where these types of abutments cannot be used.

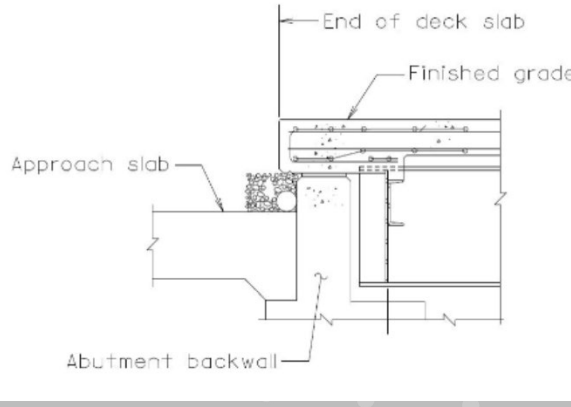


Better Solution: Eliminate Joints Where Possible
Option 3: Link Slabs

Link slabs can be used to eliminate joints along the length of the bridge.

The same concept can be used with approach slabs.





Other Drainage Problems

All components of rationally designed drainage systems need maintained.

Broken pipe of drainage system pictured.

Other Drainage Problems

Minimize use of scuppers.

Blocked scuppers pictured.

Other Considerations

- Site Selection (initial design)
- Aesthetics (initial design)
- Vegetation (initial design and maintenance)

Site Selection - UWS

Consider UWS “with caution” if:

- Environment
  1. Marine coastal areas. *How far?*
  2. Frequent high rainfall, high humidity or persistent fog (condensing conditions). *How much?*
  3. Industrial areas where concentrated chemical fumes may drift directly onto the structure. *How much?*
- Location
  1. Grade separations in “tunnel-like" conditions. *How high/wide? Salt use?*
  2. Low level water crossings. *How often?*
     a. ≤ 10 ft. over stagnant, sheltered water.
     b. ≤ 8 ft. over moving water.

Aesthetics & Substructure Staining

Wrapping the substructure during construction of uncoated steel can minimize potential staining.

Additional Notes: Minimal expense

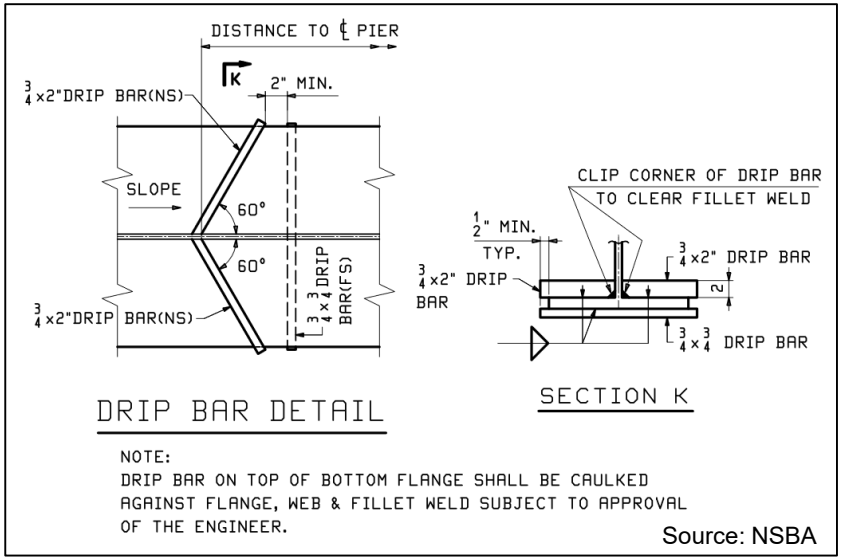
The bridge in this photo is ~20 years old. The columns were wrapped during construction and a sealer was applied after construction.

Aesthetics & Substructure Staining

Drip bars can be provided to divert water runoff from potentially staining substructure.

Caution: Do not use welded drip bars where fatigue stresses are critical!

Additional Notes: This recommended detail can be found in the AASHTO/NSBA Collaboration Document, G1.4 – Guidelines for Design Details. (aisc.org/nsba, page 104)



Vegetation

Vegetation traps moisture and should be prevented from growing in contact with structure.

SERVICE LIFE

Service Life Expectations

- **Hundreds of thousands of steel bridges in US show steel bridges perform well and can easily provide a long service life.**
- **Especially when detailed properly!!**
- **How long?**
  - Not easy to answer!!!
  - Long-term field data in realistic, representative environments is sparse
  - Numerous variables affect performance:
    - Environment (numerous environment parameters)
    - Maintenance practices
    - Workmanship

Targeted Framework for Results of Ongoing Research

Corrosion Protection System	Longevity Estimate / Category		Lifecycle Cost Estimate	
	Environment 1	Environment 2	Environment 1	Environment 2
Uncoated Grade 50W	X	Y	$A	$B
Uncoated Grade 50CR				
Galvanized, Reactive				
Metalized, 12 mils of 85/15, unsealed				
IOZ Primer Only				
OZ Paint				

Acknowledgments

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THANK YOU