Innovation

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Construction Engineer

June 3, 2021

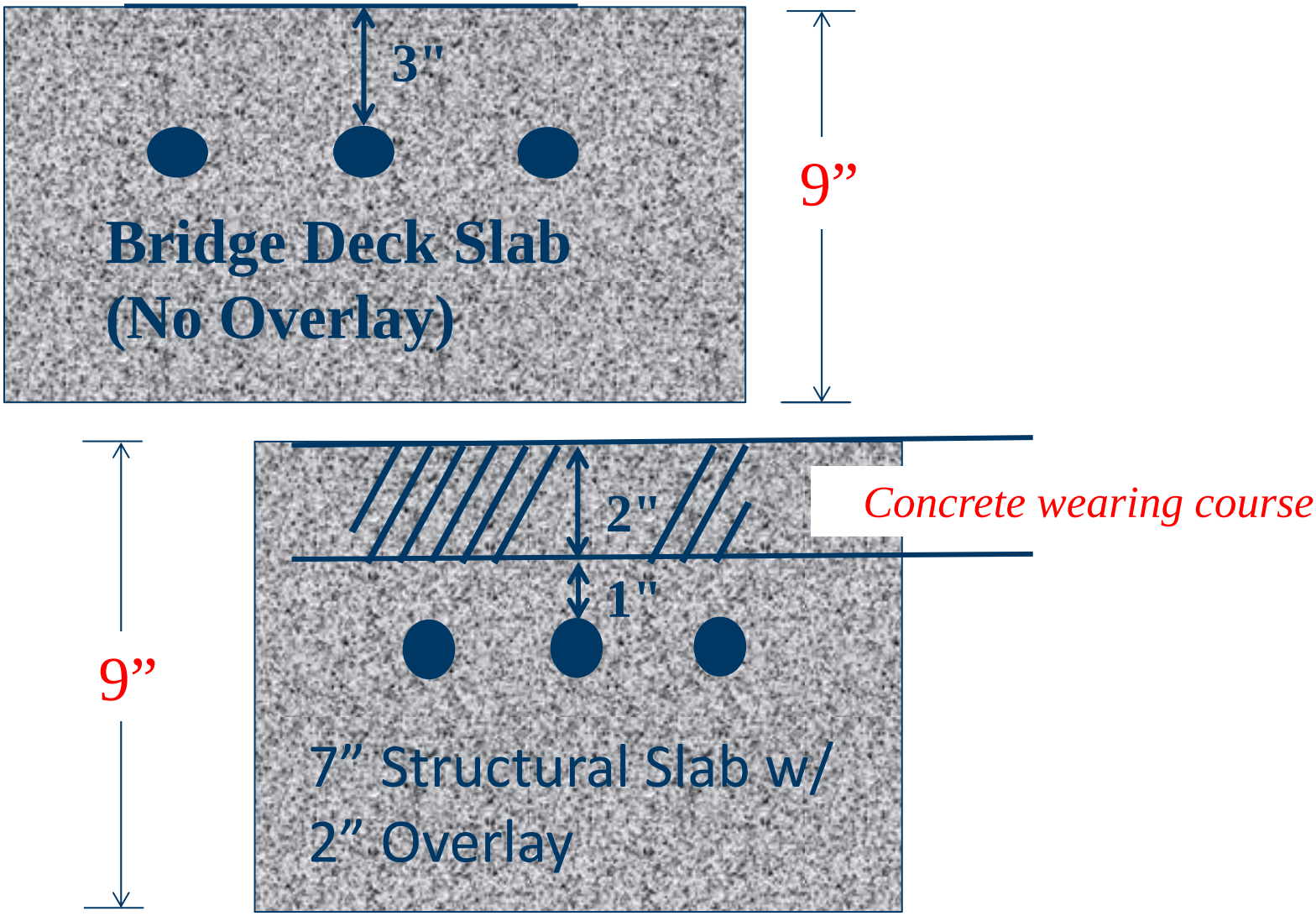
DEPARTMENT OF TRANSPORTATION

Innovation

- Deck Mix Options/Overlay Policy
- New Innovations
  - UHPC with Precast Panels
  - UHPC Beams (Near Future)
- Davidson Joint

- Discuss tracking alternative trials and process

Concrete cover over rebar



Cracking more frequent in the last 10 years.

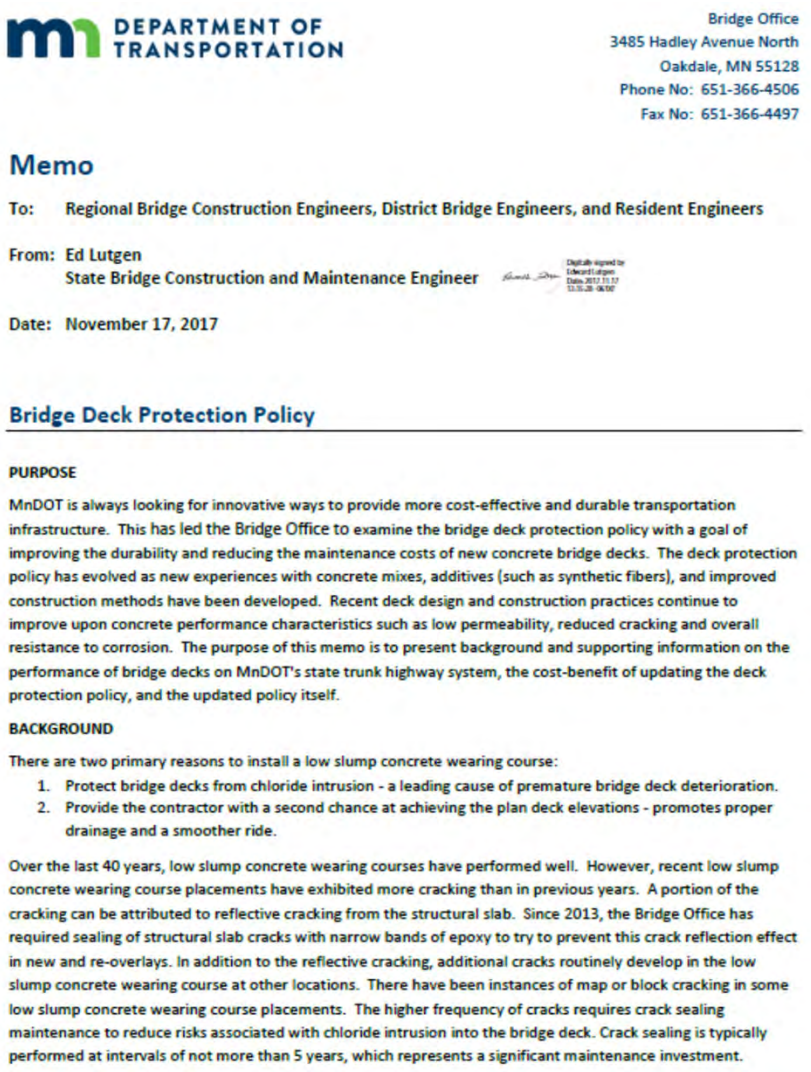
Note: The contractor had just completed crack sealing with epoxy 2 months prior to this picture. The width of the crack is exaggerated visually because of the width of the epoxy on the surface.

WB 694 – Placed in 2012
3-span slab bridge

EB 694
Re-overlay
Placed in
2017

Bridge Deck Protection Memo

- Full-depth HPC with fibers is standard
- *Exemptions for challenging conditions*



DEPARTMENT OF TRANSPORTATION

Bridge Office
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Phone No: 651-366-4506
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Memo

To: Regional Bridge Construction Engineers, District Bridge Engineers, and Resident Engineers

From: Ed Lutgen
State Bridge Construction and Maintenance Engineer

Date: November 17, 2017

Bridge Deck Protection Policy

PURPOSE

MnDOT is always looking for innovative ways to provide more cost-effective and durable transportation infrastructure. This has led the Bridge Office to examine the bridge deck protection policy with a goal of improving the durability and reducing the maintenance costs of new concrete bridge decks. The deck protection policy has evolved as new experiences with concrete mixes, additives (such as synthetic fibers), and improved construction methods have been developed. Recent deck design and construction practices continue to improve upon concrete performance characteristics such as low permeability, reduced cracking and overall resistance to corrosion. The purpose of this memo is to present background and supporting information on the performance of bridge decks on MnDOT's state trunk highway system, the cost-benefit of updating the deck protection policy, and the updated policy itself.

BACKGROUND

There are two primary reasons to install a low slump concrete wearing course:

1. Protect bridge decks from chloride intrusion - a leading cause of premature bridge deck deterioration.
2. Provide the contractor with a second chance at achieving the plan deck elevations - promotes proper drainage and a smoother ride.

Over the last 40 years, low slump concrete wearing courses have performed well. However, recent low slump concrete wearing course placements have exhibited more cracking than in previous years. A portion of the cracking can be attributed to reflective cracking from the structural slab. Since 2013, the Bridge Office has required sealing of structural slab cracks with narrow bands of epoxy to try to prevent this crack reflection effect in new and re-overlays. In addition to the reflective cracking, additional cracks routinely develop in the low slump concrete wearing course at other locations. There have been instances of map or block cracking in some low slump concrete wearing course placements. The higher frequency of cracks requires crack sealing maintenance to reduce risks associated with chloride intrusion into the bridge deck. Crack sealing is typically performed at intervals of not more than 5 years, which represents a significant maintenance investment.

Overlay Policies

2.4.1.1.2 Bridge Decks and Slabs

For bridges with reinforced concrete decks or slabs, the deck or slab may be cast in one lift (monolithic) or two lifts (deck/slab plus low slump wearing course). Note that the wearing course and the future wearing course are separate and distinct items.

Bridge Deck Protection Policy

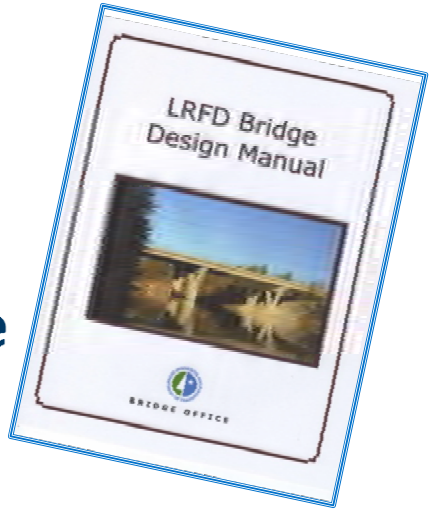
For new bridge decks and slab span superstructures, utilize:

- High Performance Concrete (3YHPC). In remote areas of the state where ready mix suppliers cannot produce 3YHPC, use Low Cracking High Performance Concrete (3YLCHPC).
- Monolithic Deck or Slab (no separate wearing course).
- Synthetic Fibers (a combination of micro and macro synthetic fibers).

Proposed Changes to Bridge Deck Wearing Course Policy…

Use Low Slump Overlays on New Bridges with:

- **Continuous Steel Superstructure with >10 degree curve**
- **Skews greater than 30 degrees**
- **Superelevation Transitions on the Deck**
- **Variable Width Bridge Decks**
- **Locations where HPC concrete is not available**
- **Constant grades less than 0.83%**
- **Vertical Curve with grades greater than 3% and skews greater than 20 degrees.**
- **Bridge deck or slab has a longitudinal construction joint**



Flex-cure alternate

SB2020-2404.3 E
Concrete Wearing Course
Pneumatically Applied
Wet Blanket Curing

Micro-Silica (Silica Fume) Wearing Course with fibers

Fogging required – dries quickly

Micro-silica wearing course is also being used on selected jobs – requires fogging and stringent evaporation control!

Micro-Silica (Silica Fume) Wearing Course with fibers

Pros

- No pass width limitation - Bidwell can be used gutter to gutter.
- Very impermeable
- Fibers easily incorporated and improve cracking performance over low slump
- Good freeze-thaw

Cons

- Must be delivered to site from plant
- Mix design risk and lead time for trials
- Scaling test results
- Slump and air variability on occasion
- Perceived as “Brittle”
- *Fogging required – dries quickly*

Deck Wearing Courses

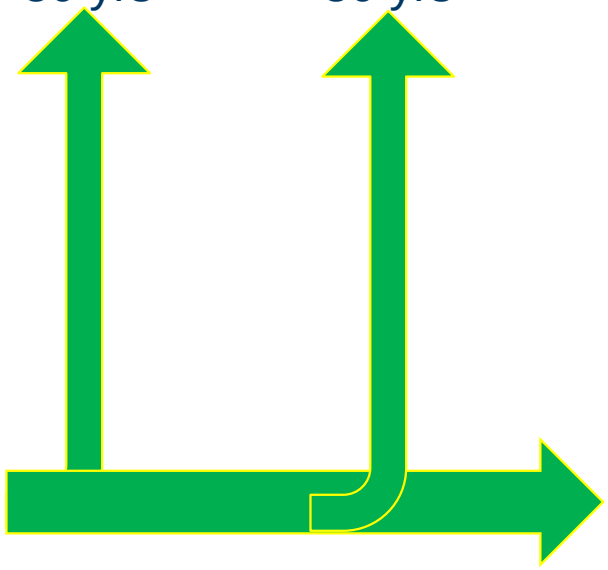
Full-depth HPC decks

LS wearing course (3U17A)

Microsilica Conc. W.C.

30 yrs

30 yrs

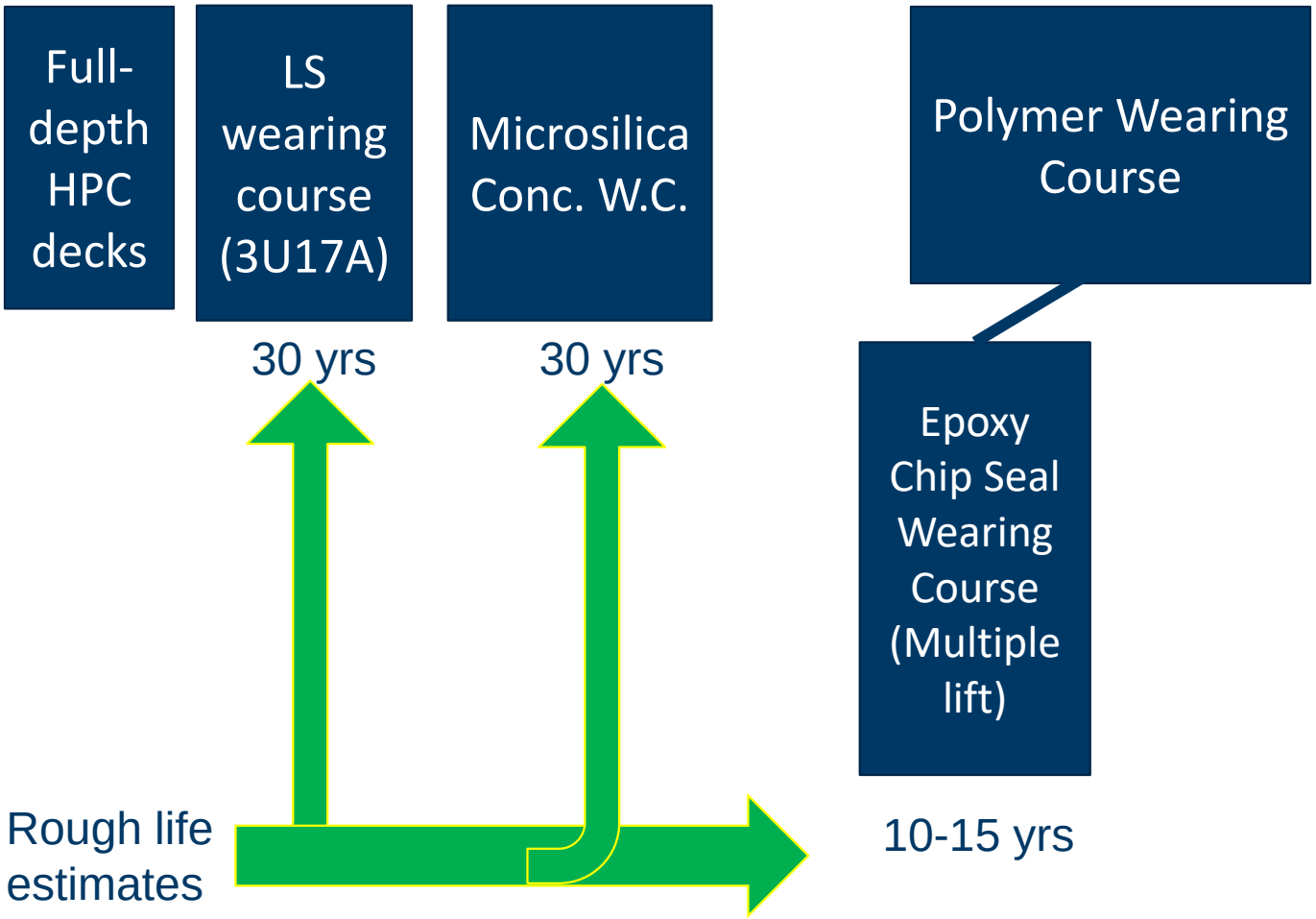


Rough life estimates

Polymer Wearing Course

- Speed of Construction
- Increased Friction Surface
- Lighter Dead Load
- No Permeability

Deck Wearing Courses



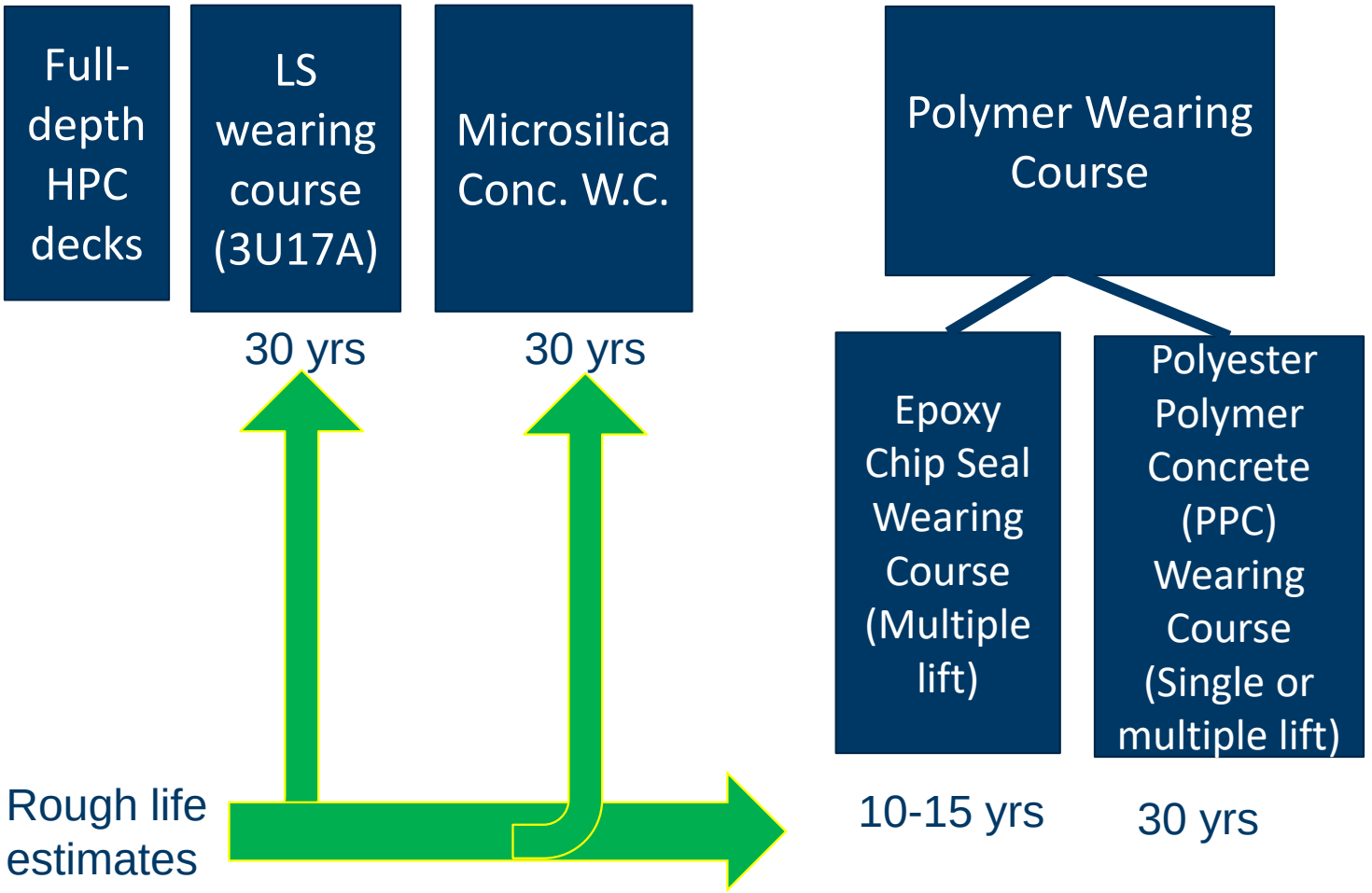
Polymer Wear Course

Multi layer epoxy chip seal

- Most common
- Epoxy or Modified Epoxy
- 2 lifts of epoxy and aggregate
- Working toward APL

- Advantages:
  - Impermeable, seals most cracks
  - Thin 3/8”, reduced weight
  - Very high friction
- Disadvantages:
  - Debonding from Deck Surface

Deck Wearing Courses



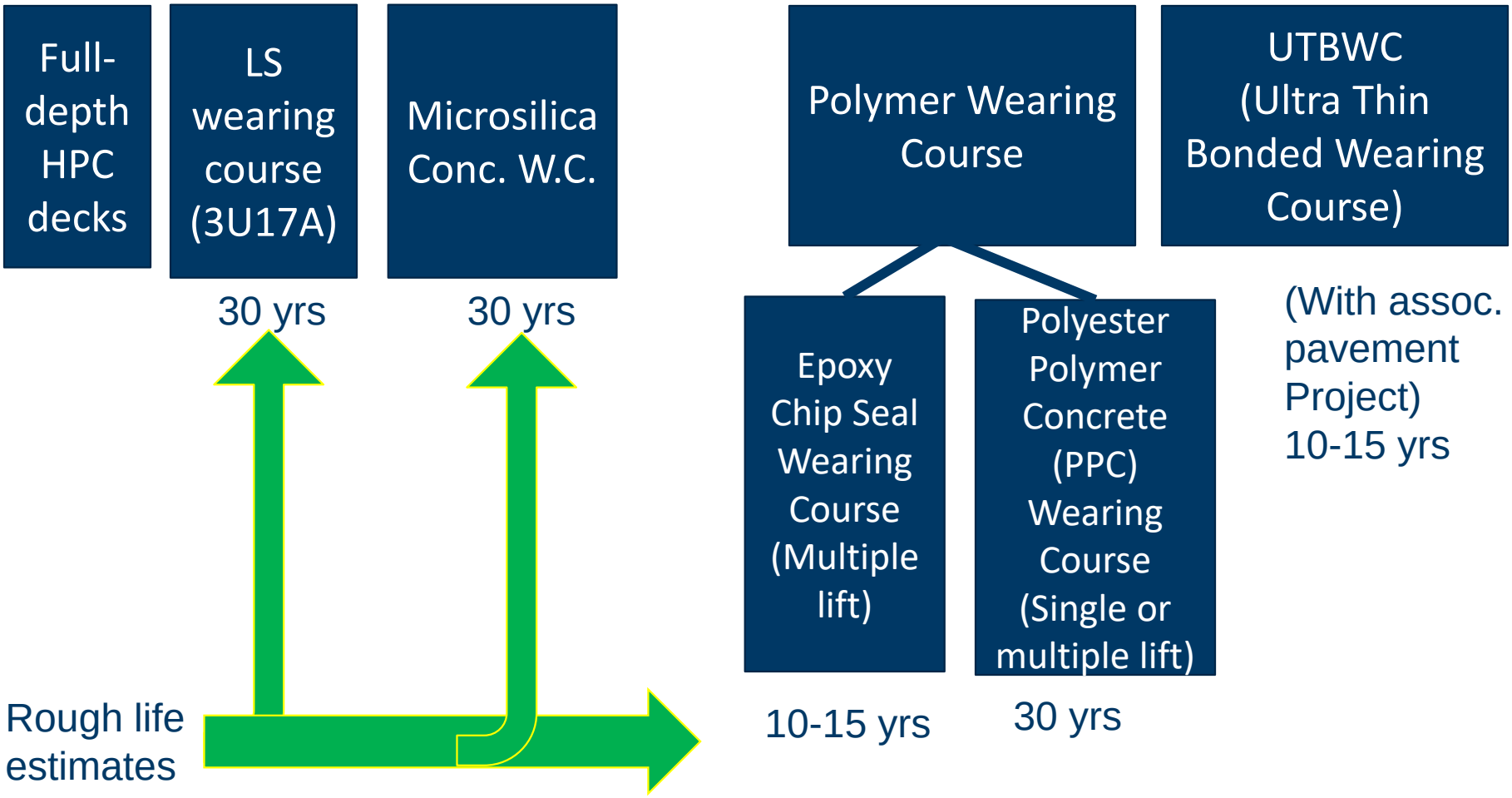
Polymer Wear Course

Polyester Polymer Concrete (PPC) Overlay

- Kwikbond
- ¾” Minimum Thickness
- High strength and elongation, great bond

- Advantages:
  - Cure rapidly, returning traffic quickly to the site
  - Outlasts all existing materials
- Disadvantages:
  - Cost

Deck Wearing Courses



Ultra Thin Bonded Wearing Course (UTBWC)

- Also known as Novachip
- Scoped with paving job
- 5/8” to ¾” thick on bridge

Pros:

- Provides chloride barrier and some waterproofing capability at low cost
- Cost effective
- Fast Application
- Performs better than original asphalt overlays due to density

Ultra Thin Bonded Wearing Course (UTBWC)

Cons

- No cross slope breaks within same pass
- Asphalt rounds off and can deteriorate at expansion joints- requires polymer header for best practice
- May need more salting, more prone to icing
- More freeze-thaw cycles due to heat attraction
- Heavy paving train- load rate bridge for construction operation

Ultra Thin Bonded Wearing Course (UTBWC)

2008 Installation on Overpass
(Photo from Google 2017)

7 years in service
(Photo from Google Nov 2015)

Ultra Thin Bonded Wearing Course (UTBWC)

Cons

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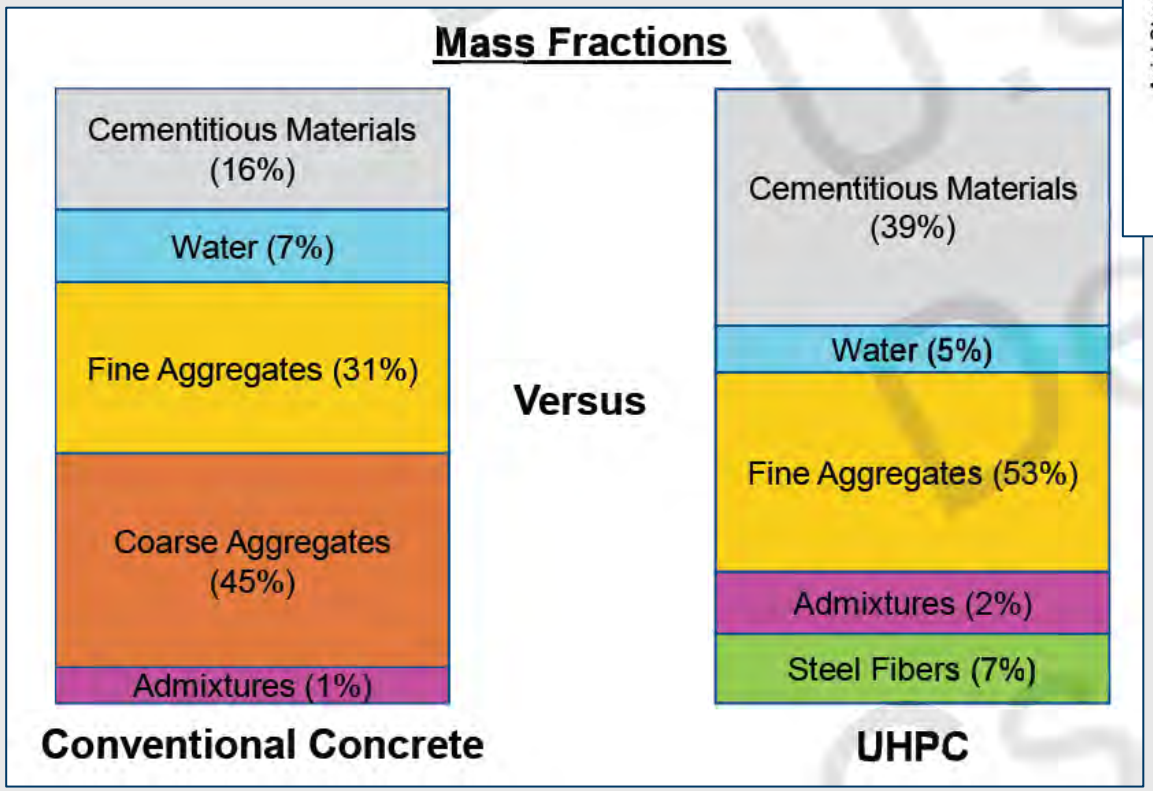
Ultra Thin Bonded Wearing Course (UTBWC)

- Apply hot pour/mastic at gutterline and partially up barrier because paver leaves an unprotected gap

Ultra High Performance Concrete (UHPC)



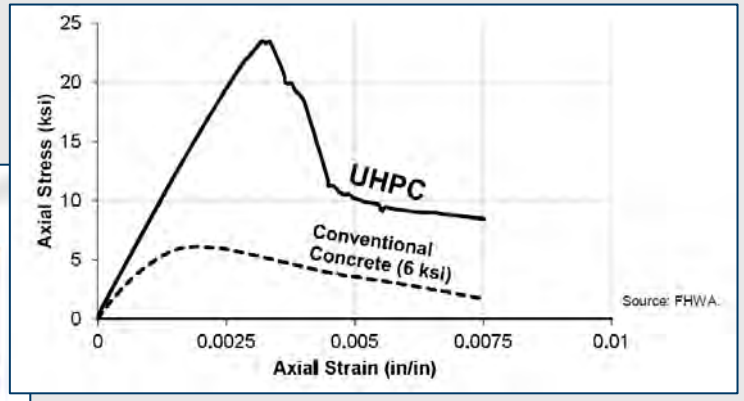


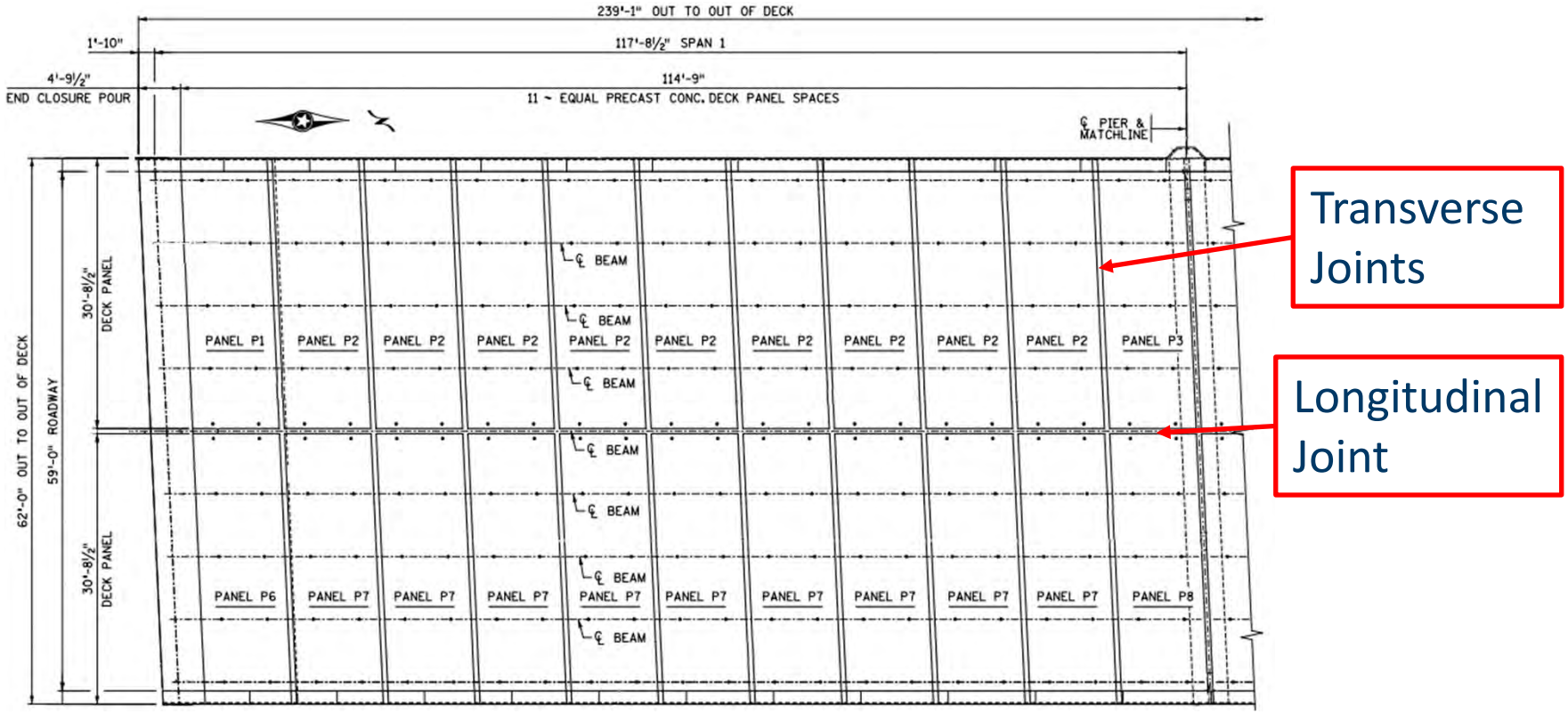
Image credit: Turner-Fairbank Highway Research Center

Innovations - UHPC with Precast Panels

Photo by WSP USA Inc.

Precast panels with UHPC

- All panels the same size
- 7” Joints

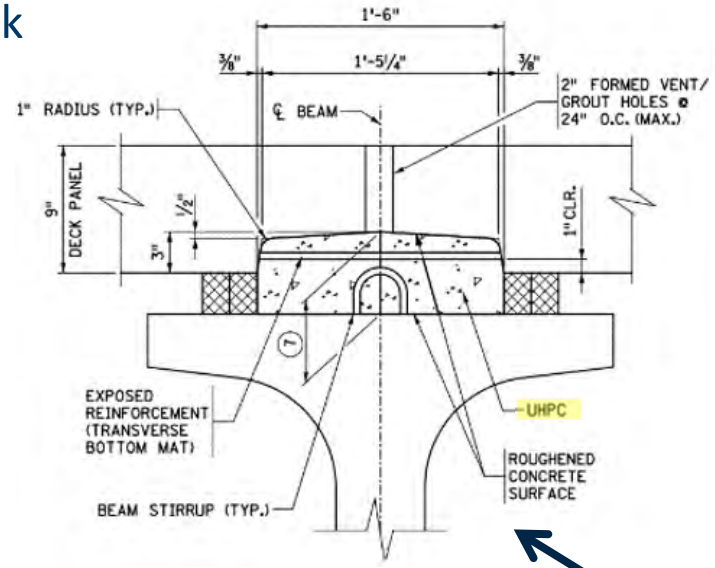


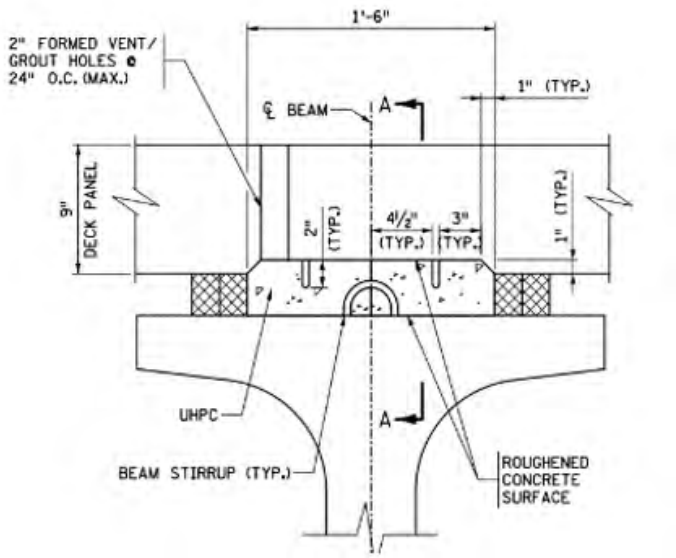
Innovations - UHPC with Precast Panels

Photo by WSP USA Inc.

Precast panels with UHPC

- Desire for limited deck penetrations
- “Hidden pocket” connection
- Multiple alternate details
- Detail using bottom transverse mat of panel steel selected
- Trade off between UHPC volume, forming complexity and build tolerances



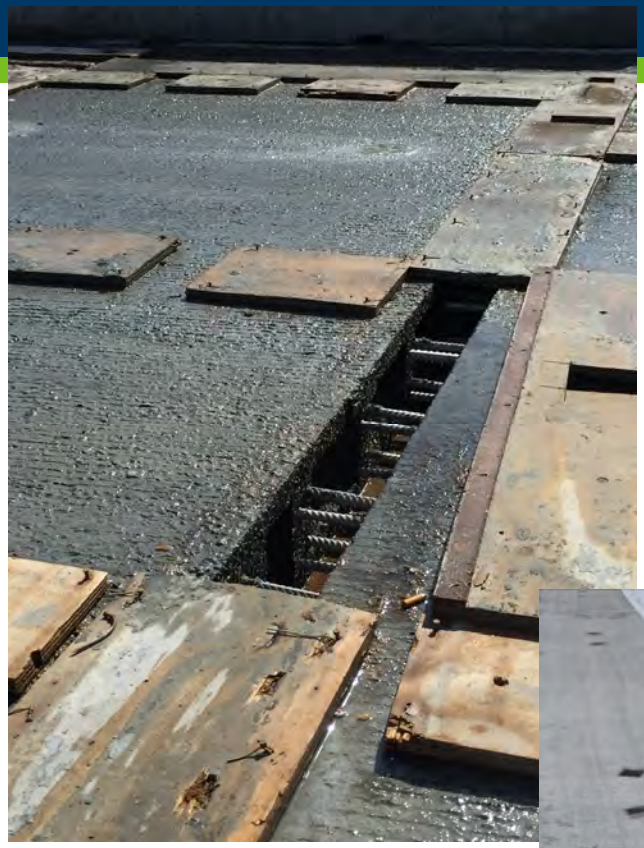


Alternate

Used

Erection and UHPC placement

Precast panels with UHPC



2019 Project with UHPC

UHPC

- Advantages:
  - 48-hour cure to 18,000psi
  - Strong in tension
  - Splice rebar in 6 diameters
  - Self Consolidating, highly flowable
  - Impermeable to chlorides
- Disadvantages:
  - $$$$, small 2-3 yard batches
  - Shrinkage slightly higher
  - Few sources, somewhat specialized QC
  - Needs exposed agg and pre-wetted surface to bond well
  - Difficult to repair
  - Forms a crust on surface that must be ground off due to porosity

UHPC Beams

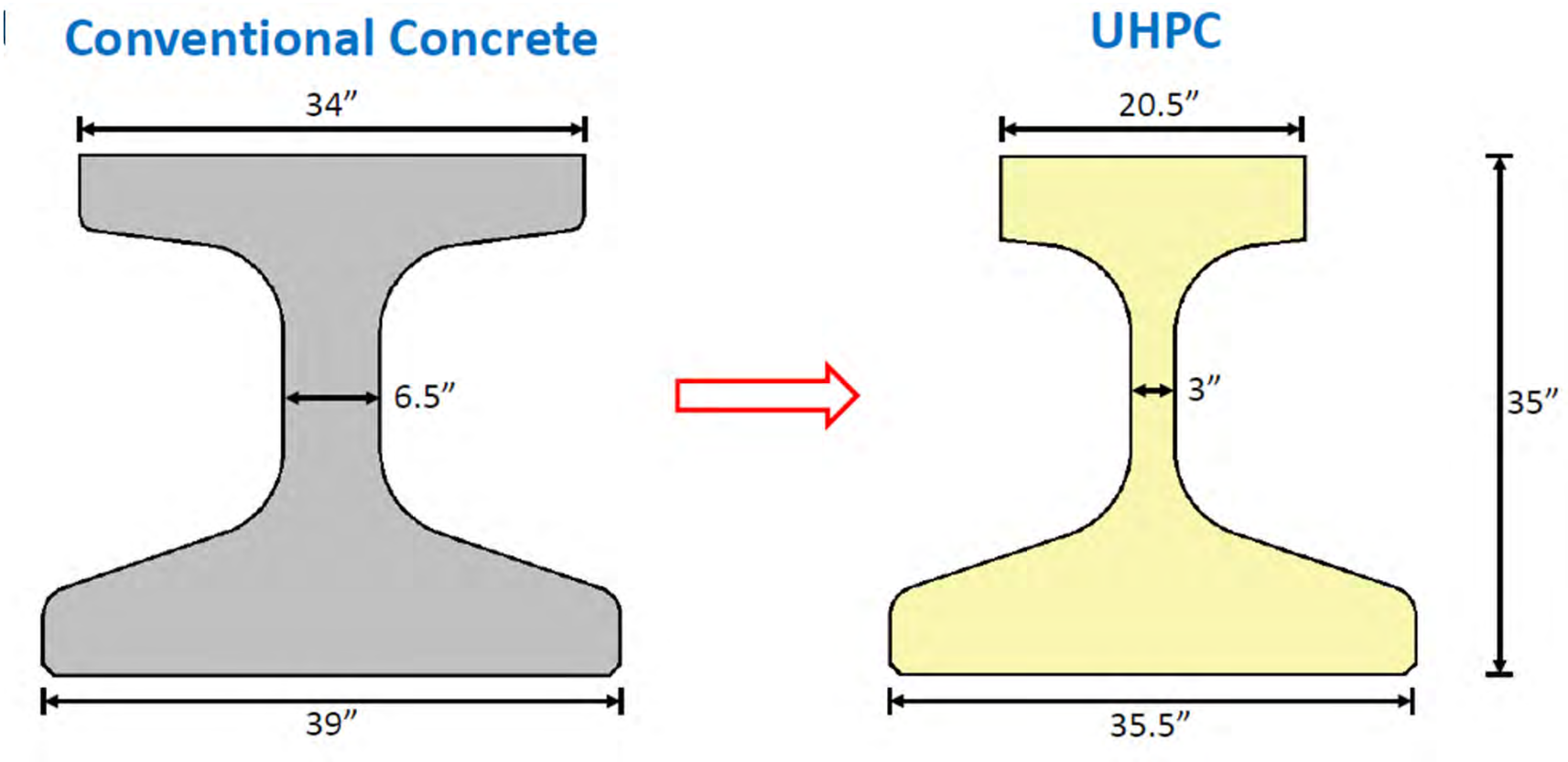
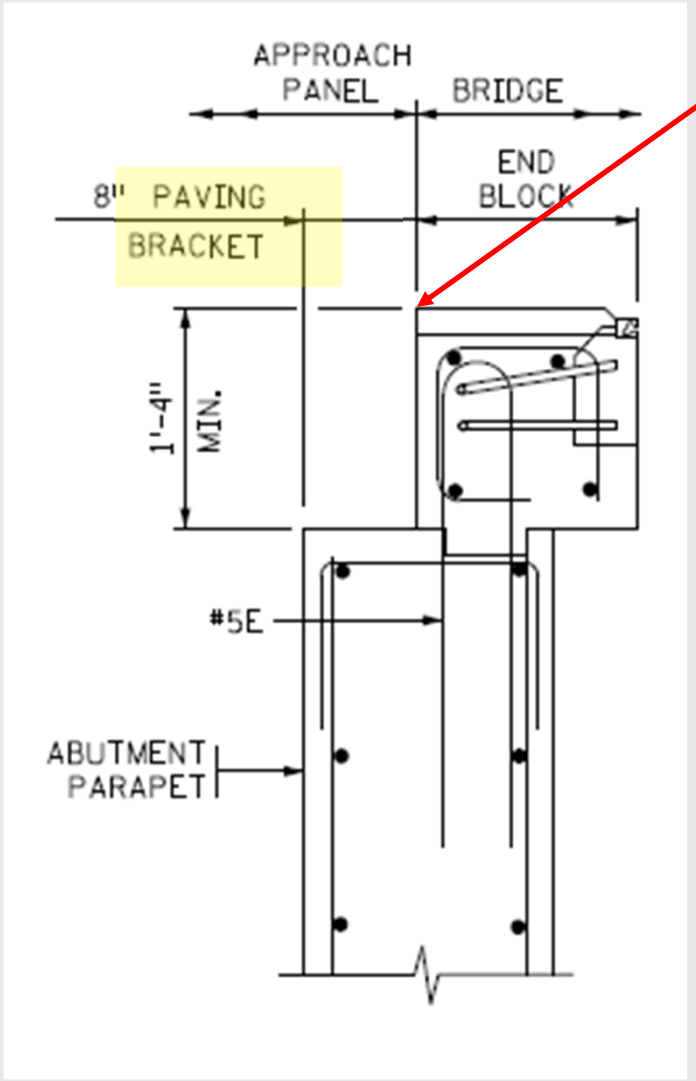


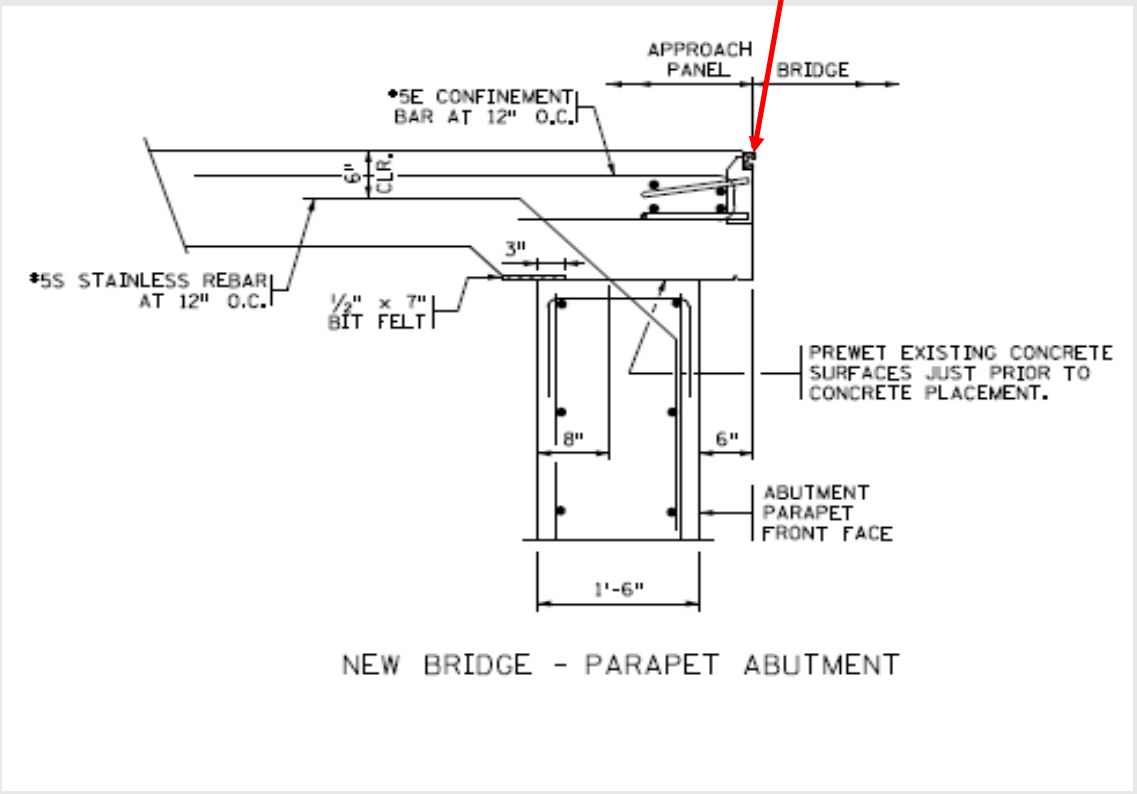
Image credit: Ben Graybeal, FHWA

Davidson Detail – New Bridge



BEGIN/END of Bridge

BEGIN/END of Bridge

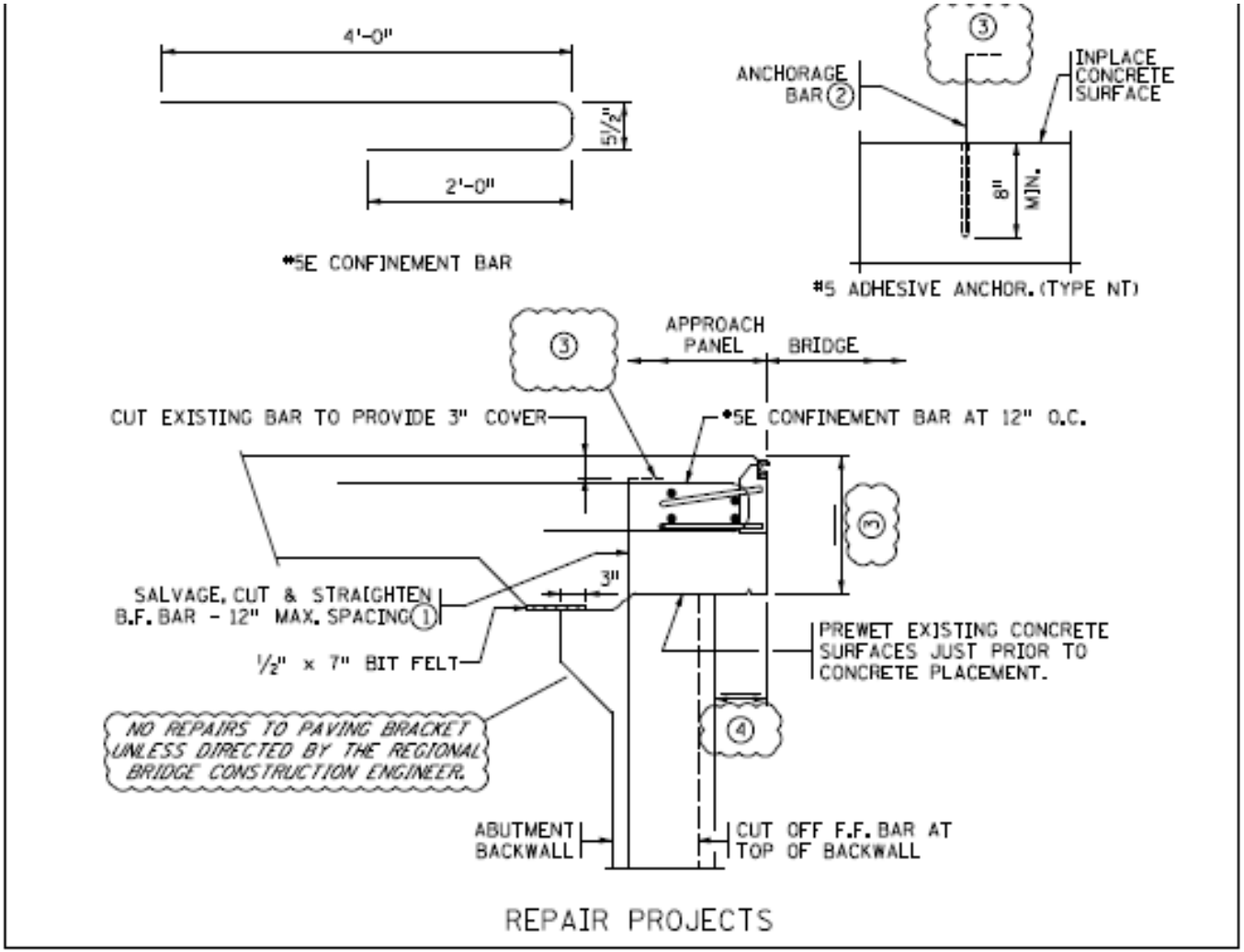


NEW BRIDGE - PARAPET ABUTMENT

Davidson Detail – New Bridge

- Exceptions to the Rule:
  - Long-term approach settlement greater than ½” is expected.
  - Modular joints are used at the abutment.

Davidson Detail – Repair Projects



Tracking Design, Construction, Material, and Research Trials

What?

- Implement process for tracking bridge research, design, construction, and materials trials

Why?

- Ensure data is available, accessible, transparent, and organized in order to evaluate long-term performance and facilitate future decisions

How?

- Shared spreadsheet or SharePoint site
- SIMS (Structure Information Management System)

Ashley Grzybowski

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