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TRANSPORTATION RESEARCH BOARD

Fixing the Bump at the End of the Bridge

August 30, 2021

@NASEMTRB
#TRBwebinar

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- 1.5 Professional Development Hour (PDH) – see follow-up email for instructions
- You must attend the entire webinar to be eligible to receive PDH credits
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RCEP

REGISTERED CONTINUING EDUCATION PROGRAM

#TRBwebinar

Learning Objectives

1. Design bridge ends and approach pavements

2. Identify design elements on abutments, approach slab, embankment, and drainage

NCHRP 20-68A
US Domestic Scan Program
Domestic Scan 19-01

"Leading Practices for Detailing Bridge Ends and Approach Pavements To Limit Distress and Deterioration"

Findings, Conclusions and Recommendations

NCHRP 20-68A U. S. Domestic Scan Program

The Program is a multi year project conducting 3-4 scans per year.

Each scan is selected by AASHTO and the NCHRP 20-68D Project Panel

Each scan addresses a single technical topic of broad interest to many state departments of transportation and other agencies

The purpose of each scan and of Project 20-68D as a whole is to accelerate beneficial innovation by:

facilitating information sharing and technology exchange among the states and other transportation agencies

identifying actionable items of common interest

NCHRP Panel's General Guidance to the Scan Team

"Meet with agencies having experience in dealing with distresses observed on approaches to jointless bridges and explore leading-edge solutions

Identify tools that can assist in the selection of the appropriate details for use at the ends of bridges.

Share tools and information nationwide to improve the performance and durability of bridge ends."

NCHRP Panel's General Guidance to the Scan Team (Cont.)

"*The key information to be gained is the identification of details that have been implemented at the ends of structures …such as:*

1) Isolating the approach slab from the backfill material beneath it at the end of the bridge to allow for adequate movement.

2) Connections between components at the ends of bridges including, but not limited to bridge decks, abutment backwalls, abutments, abutment foundations, and the approach pavement.

3) Structure length, substructure skew, and other geometric characteristics that dictate the use of unique components or details.

NCHRP Panel's General Guidance to the Scan Team (Cont.)

"*The key information to be gained is the identification of details that have been implemented at the ends of structures …such as:*

4) End of bridge drainage systems

5) Supporting design calculations critical to the resolution of issues.

6) Rehabilitation solutions to repair the deterioration and distress associated with the details at the ends of bridges that are not functioning as anticipated.

7) Seismic participation of bridge abutments and embankments"

NCHRP Panel's Anticipated Outcomes

"The scan report will provide current information on detailing bridge ends and approach pavements to limit distress and deterioration by sharing both successes and lessons learned.

The audience for this information includes state and local bridge design engineers and geotechnical engineers who can use the information to improve the end of bridge details currently in use."

Scan Team

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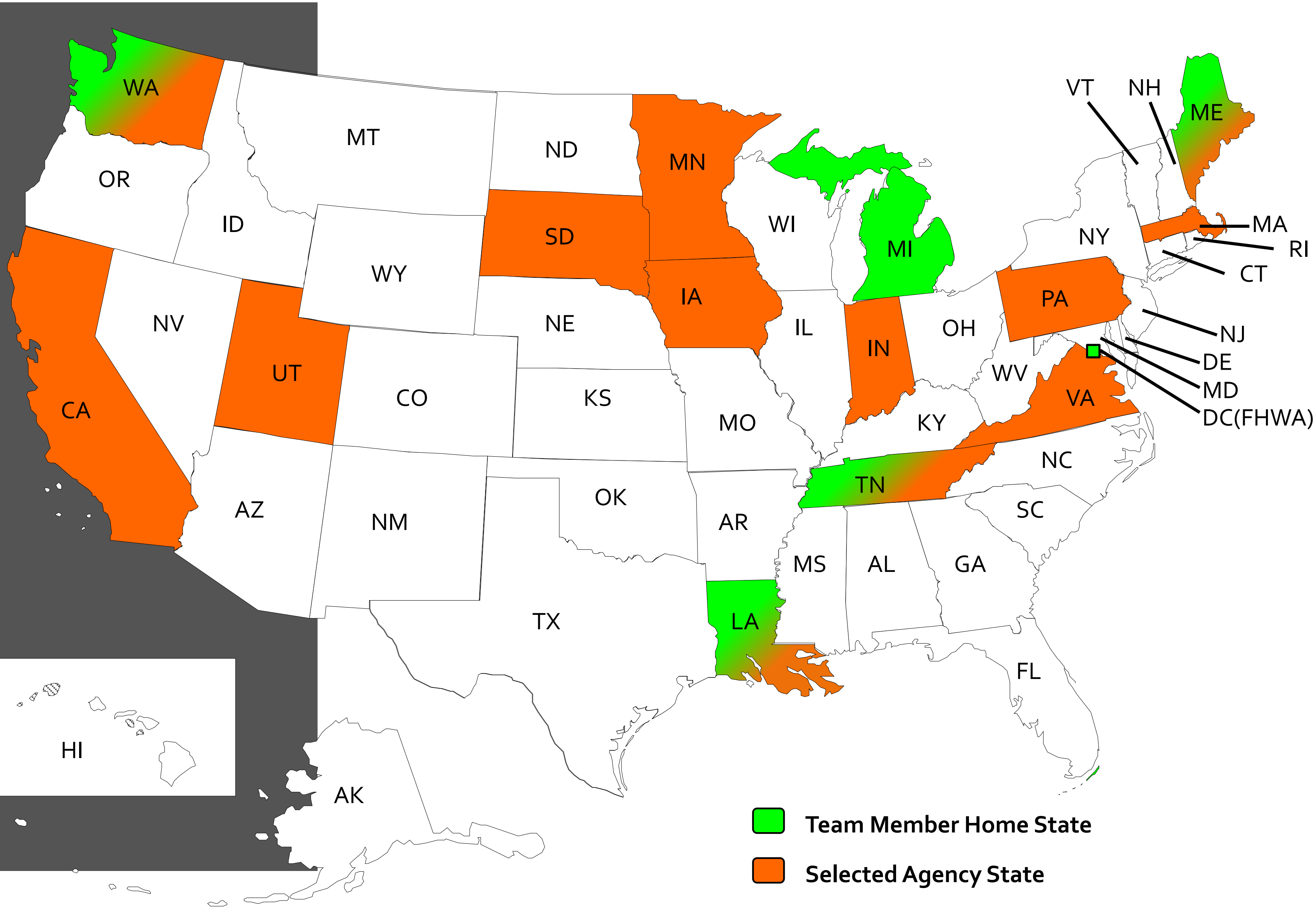
Tennessee DOT

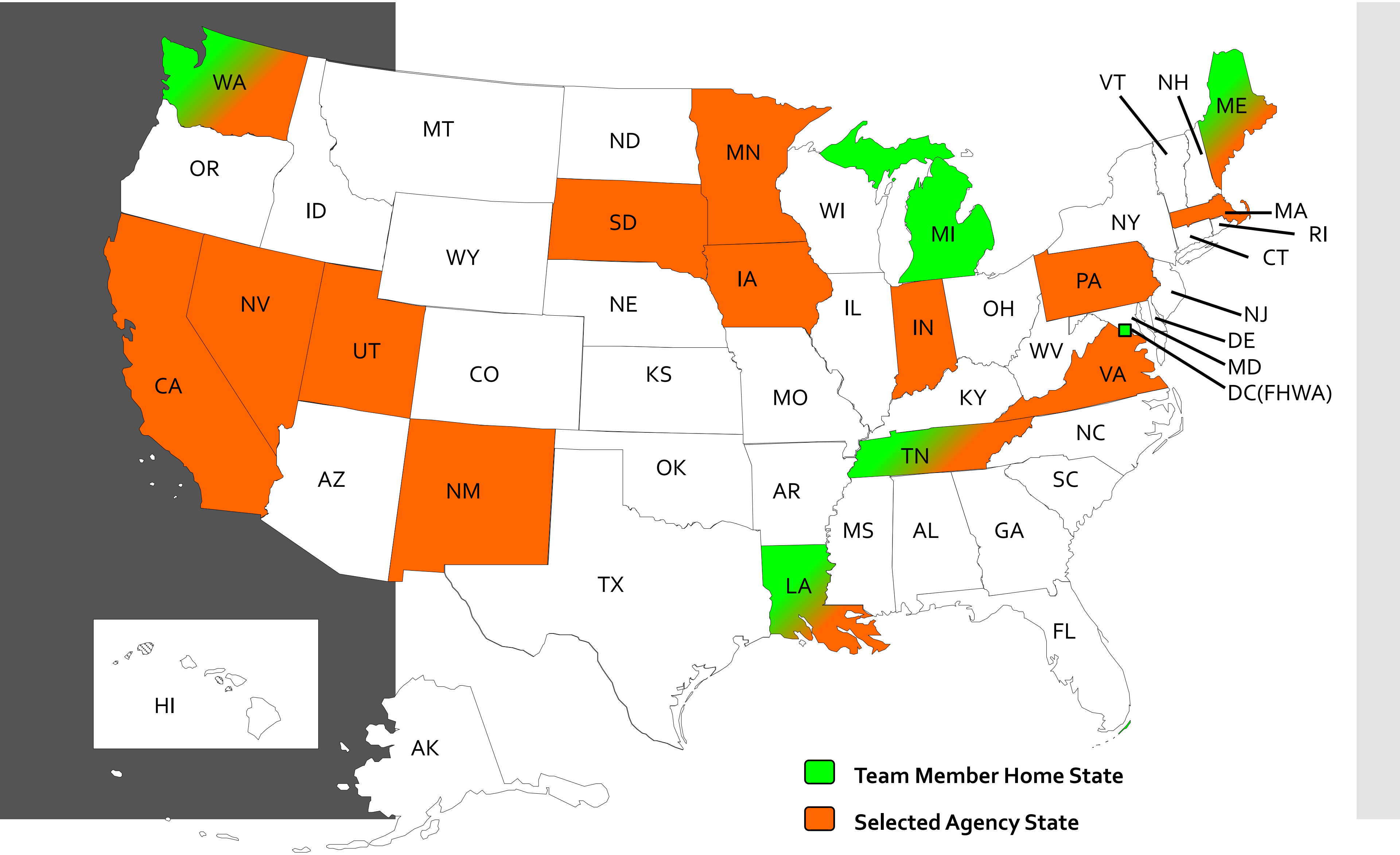
Romeo R. Garcia
Bridge Construction Engineer
Office of Infrastructure
Construction Management Team
Federal Highway Administration (FHWA)

Jill Walsh, Ph.D., P.E. - Subject Matter Expert
Assistant professor
Saint Martin's University

Scan 19-01 State Map



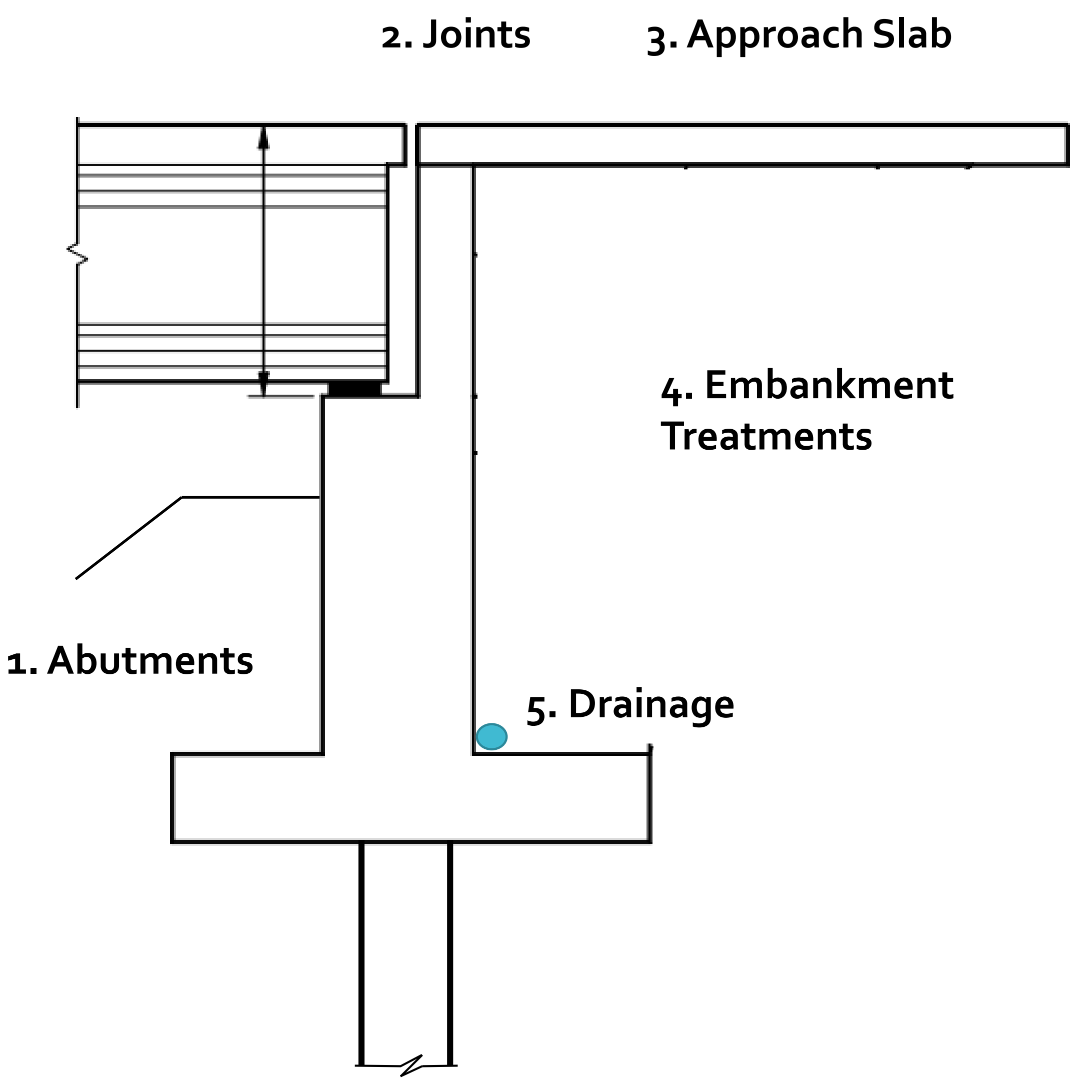
Scan 19-01 State Map



Problems Associated with the Bump Issue

Categorized By Bridge End Regions

1. Abutments
2. Joints
3. Approach Slabs
4. Embankment
5. Drainage



Problems Associated with the Bump Issue

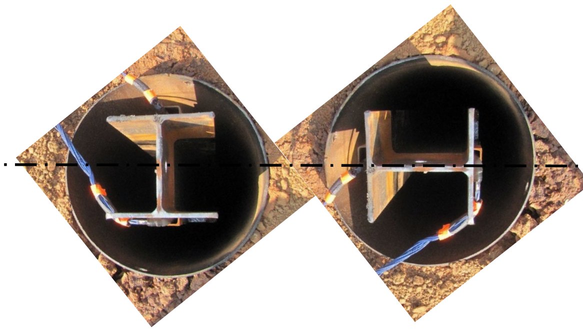
1. Abutments

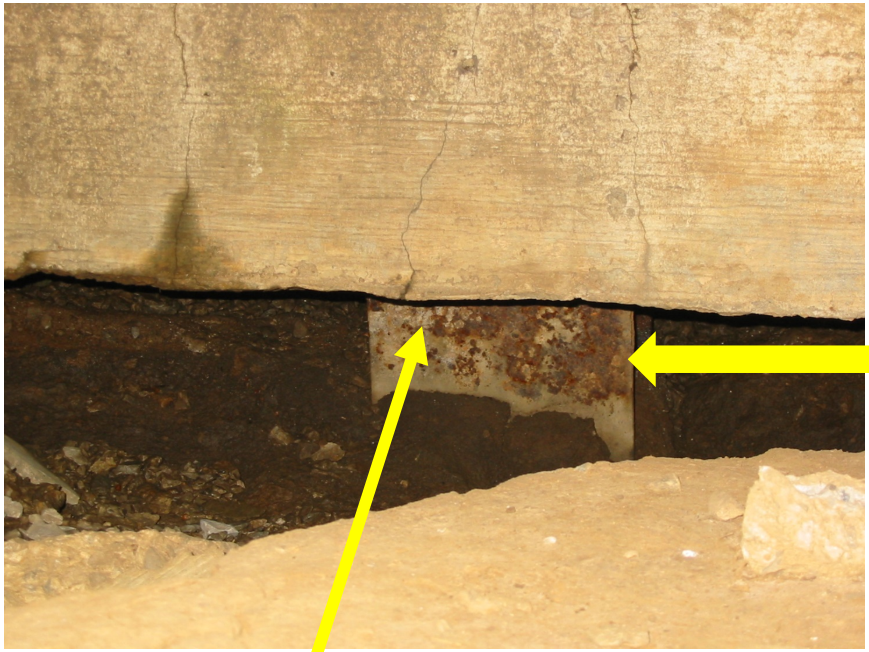
Issues Discussed:

- Settlement of fill
- Erosion of fill
- Steel Pile Corrosion
- Pile Orientation
- Embedment depth

Problems Associated with the Bump Issue

1. Abutments





Problems Associated with the Bump Issue

1. Abutments

Steel Pipe Piles
Prestressed Concrete Piles
Strong Axis Only

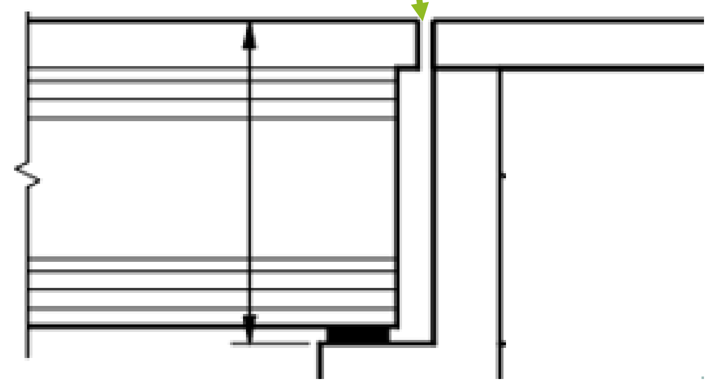
Embedment depth

Problems Associated with the Bump Issue

2. Joints

Joint Location

Joint Type



Domestic Scan 17-03
Performance of Bridge Bearings and Expansion Joints

Problems Associated with the Bump Issue

2. Joints

Pros of Eliminating Joints

Joints are expensive and need routine maintenance

Joints leak, stain, and cause corrosion on bearings

Joints leaking can promote deck / beam end deterioration

Water born salts penetrating joints promote deterioration.

Joint leakage causes deterioration of beam ends, bearings, substructures requiring continued on-going maintenance.

Cons of Eliminating Joints

Need to consider erosion around abutments and berm areas

Approach pavement can slip off paving support

Corrosion of piling under abutment footing

Damage to top of deck from snow plow impact at joint due to settlement of approach pavement

Thermal restraint resulting in deck cracking

Problems Associated with the Bump Issue

2. Joints

Joints paved over to mitigate the bump which is detrimental to joint operation.

Joints collect road debris leading to the failure of the joint gland.

Problems Associated with the Bump Issue

2. Joints

Joint leakage can lead to deterioration on both steel and concrete beam ends.

Joint leakage can cause joints to freeze and deteriorate limiting the useful life and overall operation.

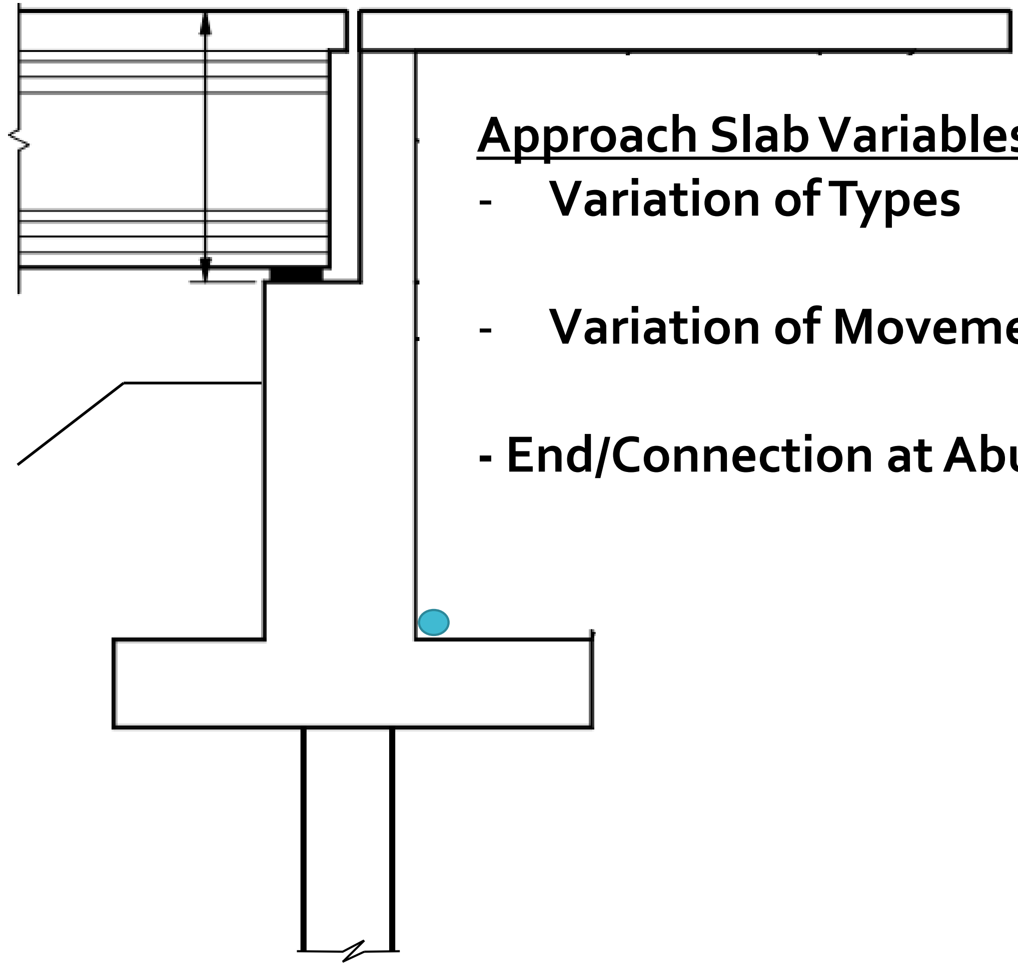
Deterioration can extend into the substructures resulting in loss of bearing area and overall concrete deterioration.

Problems Associated with the Bump Issue

2. Joints

Problems Associated with the Bump Issue

3. Approach Slabs



<u>Approach Slab Variables</u>

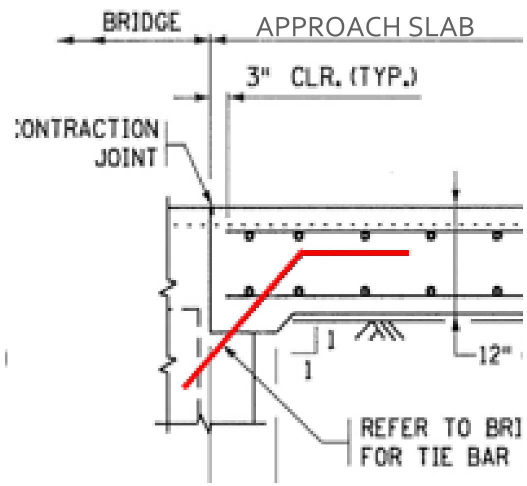
- **Variation of Types**

- **Variation of Movement**

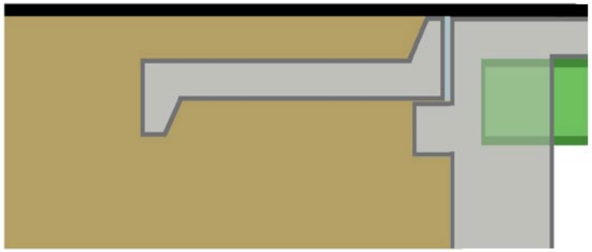
- End/Connection at Abutment

Problems Associated with the Bump Issue

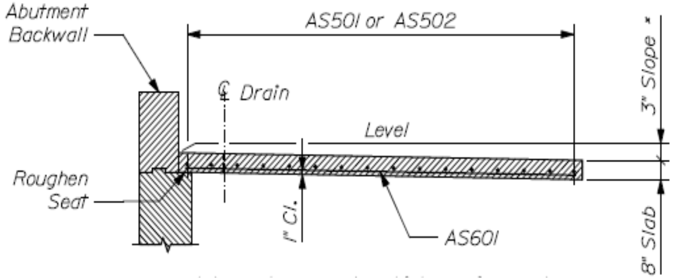
3. Approach Slabs



Slab is the riding surface and moves with Abutment



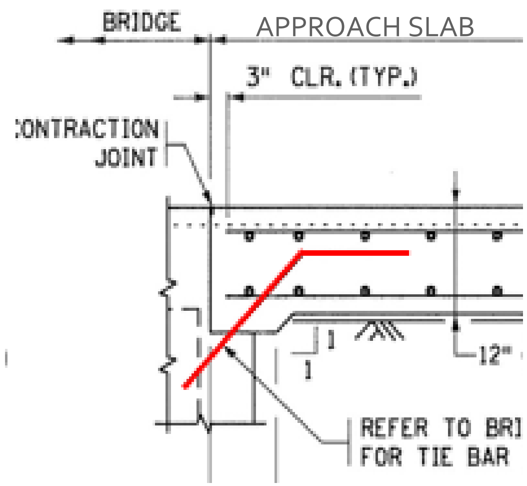
Slab lowered to (intentionally) allow pavement as riding surface



Slab is buried "feet" below riding surface with full depth roadway section as riding surface.

Problems Associated with the Bump Issue

3. Approach Slabs

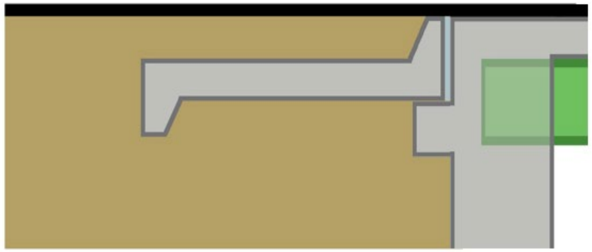


Identified problems

- Bump with skewed or perpendicular approach alignment
- Approach fill settled under slab leading to distress
- Slab did not move with abutment resulting in abutment damage
- Open joints along edges allowed water to foul approach fill

Problems Associated with the Bump Issue

3. Approach Slabs

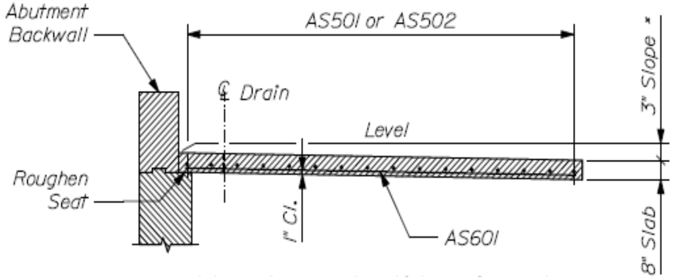


Identified problems

- Reflective cracks developed regardless of the approach alignment
- Approach fill settled under slab leading to distress
- Pavement cracks developed at abutment that allowed water to damage abutment piles.

Problems Associated with the Bump Issue

3. Approach Slabs



Identified problems

- Problematic in rocky terrain
- Difficult to repair if problems develop

Problems Associated with the Bump Issue

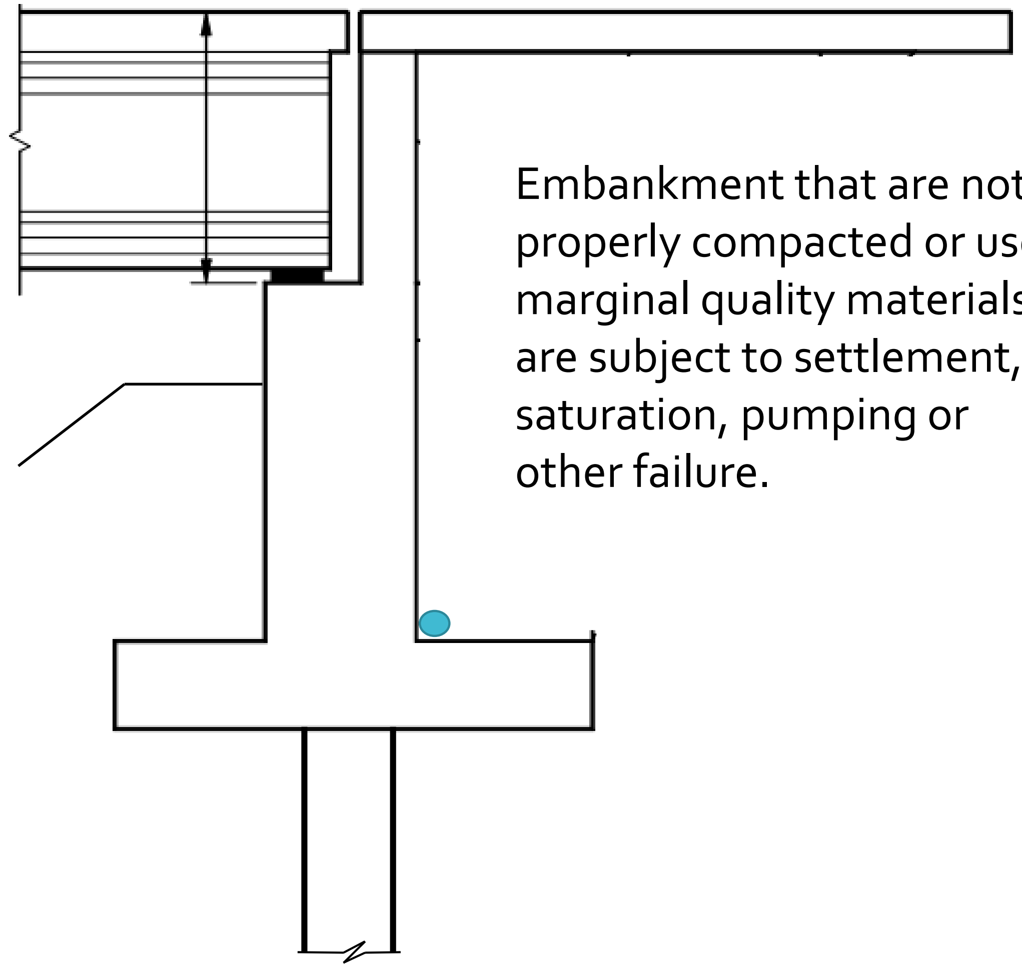
3. Approach Slabs

Slab settles causing bump and also allowing water to seep into the approach embankment and also lead to damage at the abutments.

Settled slab will rotate at the abutment leading to rideability issues and, possible joint damage.

Problems Associated with the Bump Issue

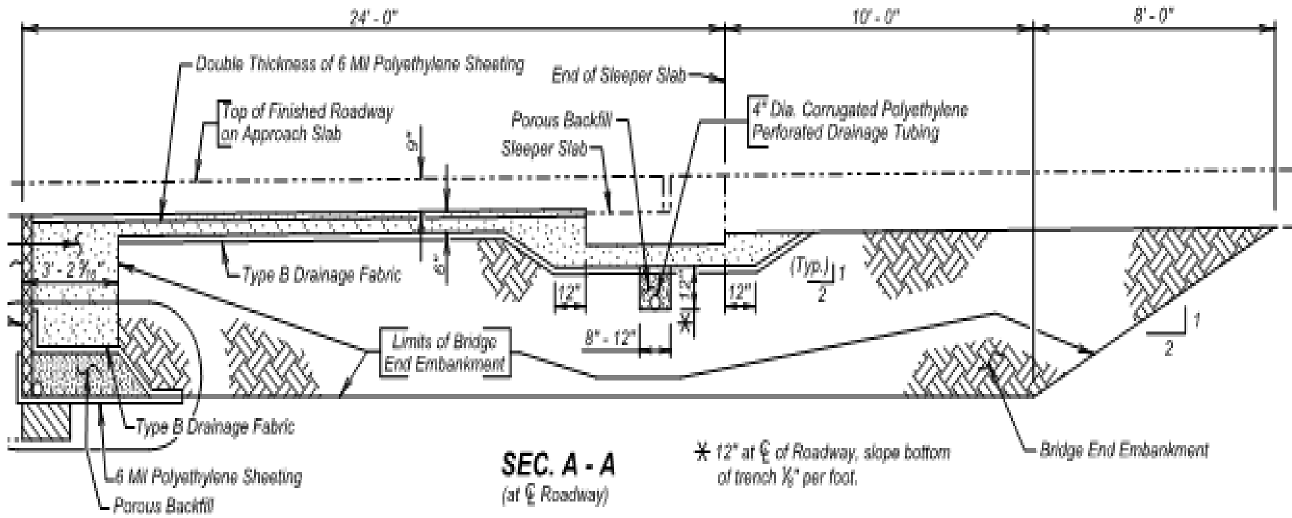
4. Embankment



Embankment that are not properly compacted or use marginal quality materials are subject to settlement, saturation, pumping or other failure.

Problems Associated with the Bump Issue

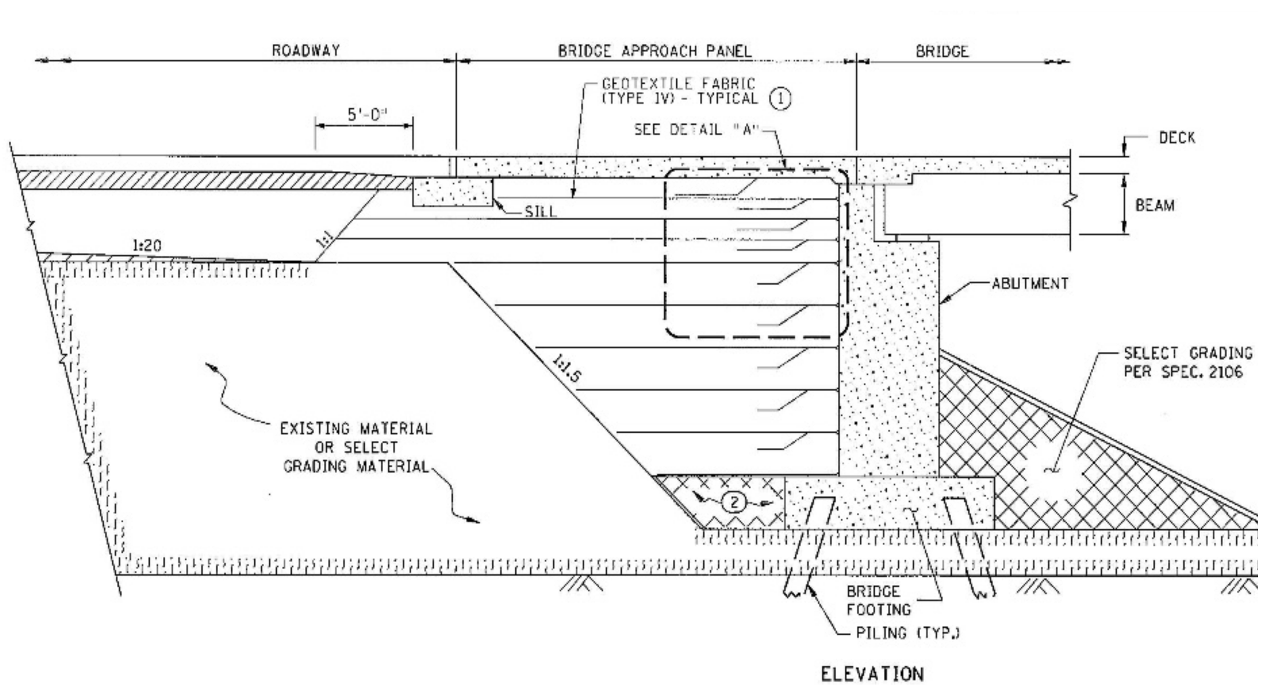
4. Embankment



Improper placement of open graded backfill on traditional backfill can result in saturated soils that can lead to pavement failures and settlement of the approach slabs.

Problems Associated with the Bump Issue

4. Embankment



Adding engineered fills can help reduce settlement when properly installed. Improper installation can lead to erosion under the abutment and damage to pile supports.

Problems Associated with the Bump Issue

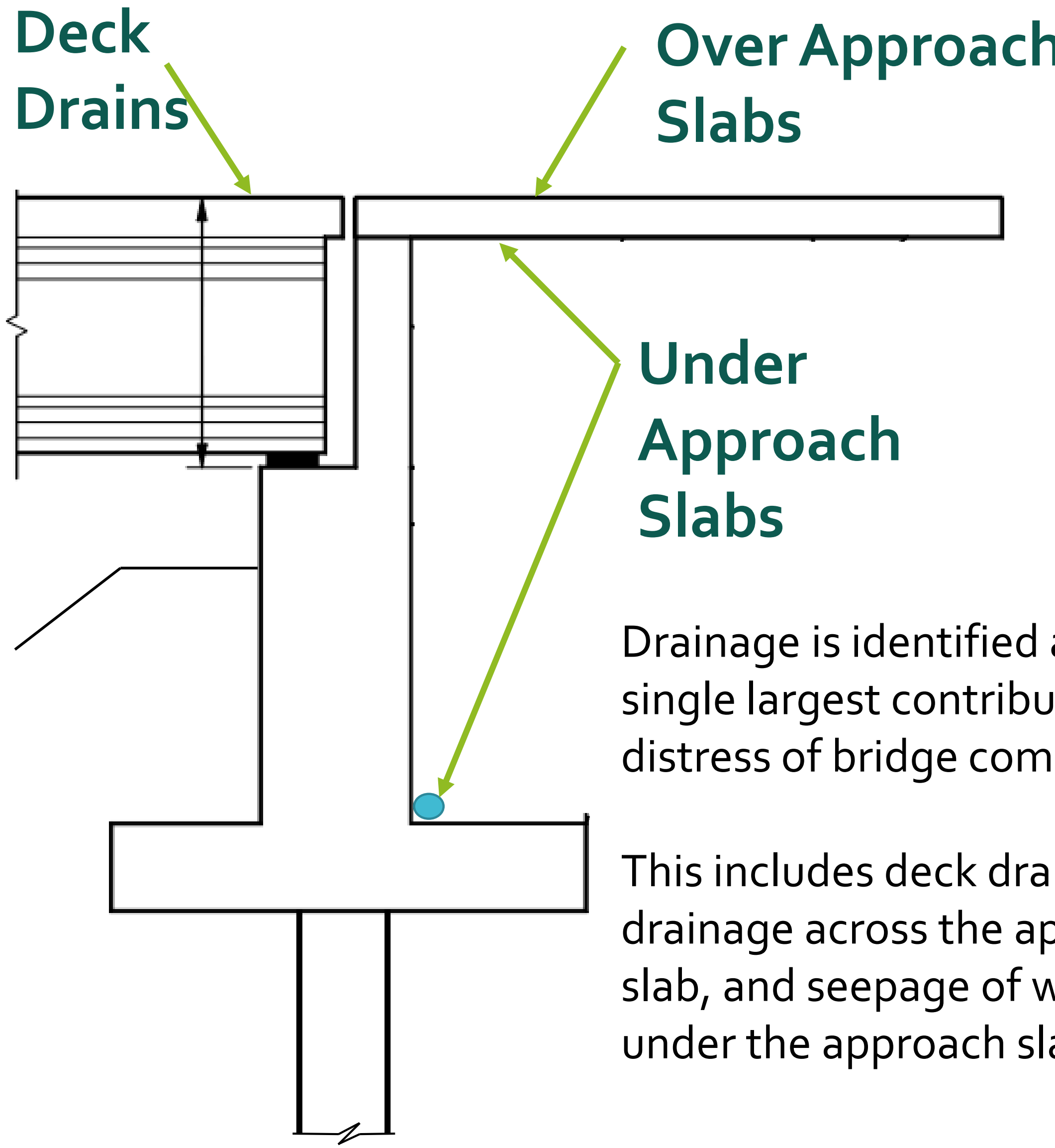
4. Embankment

Poor draining soil and poorly compacted fill behind abutments compound settlement issues.

Settlement under the slab promotes drainage issues and can result in slab dropping from support.

Problems Associated with the Bump Issue

5. Drainage



Drainage is identified as the single largest contributor to distress of bridge components.

This includes deck drainage, drainage across the approach slab, and seepage of water under the approach slab.

Problems Associated with the Bump Issue

5. Drainage

Some states mentioned that open deck drains are not permitted on many structures.

Water flowing along the bridge rail or curb will find cracks along the bridge surface and seep in to cause damage.

Problems Associated with the Bump Issue

5. Drainage

Clogged drains in the approach slab will allow water to find other paths that naturally cause damage to the bridge structure of approach roadway fills.

Problems Associated with the Bump Issue

5. Drainage

Water seeping from the bridge surface will cause deterioration or other structural damage.

Corrosion of structural steel, prestressing strands or rebar will shorten the service life of various components and increase the overall maintenance costs of bridge assets.

Solutions and Best Practices

NOTE:

Not All Best Practices Work for All Agencies

Very Wide Variation in Styles and Details

Drainage

Backfill Compaction/Placement

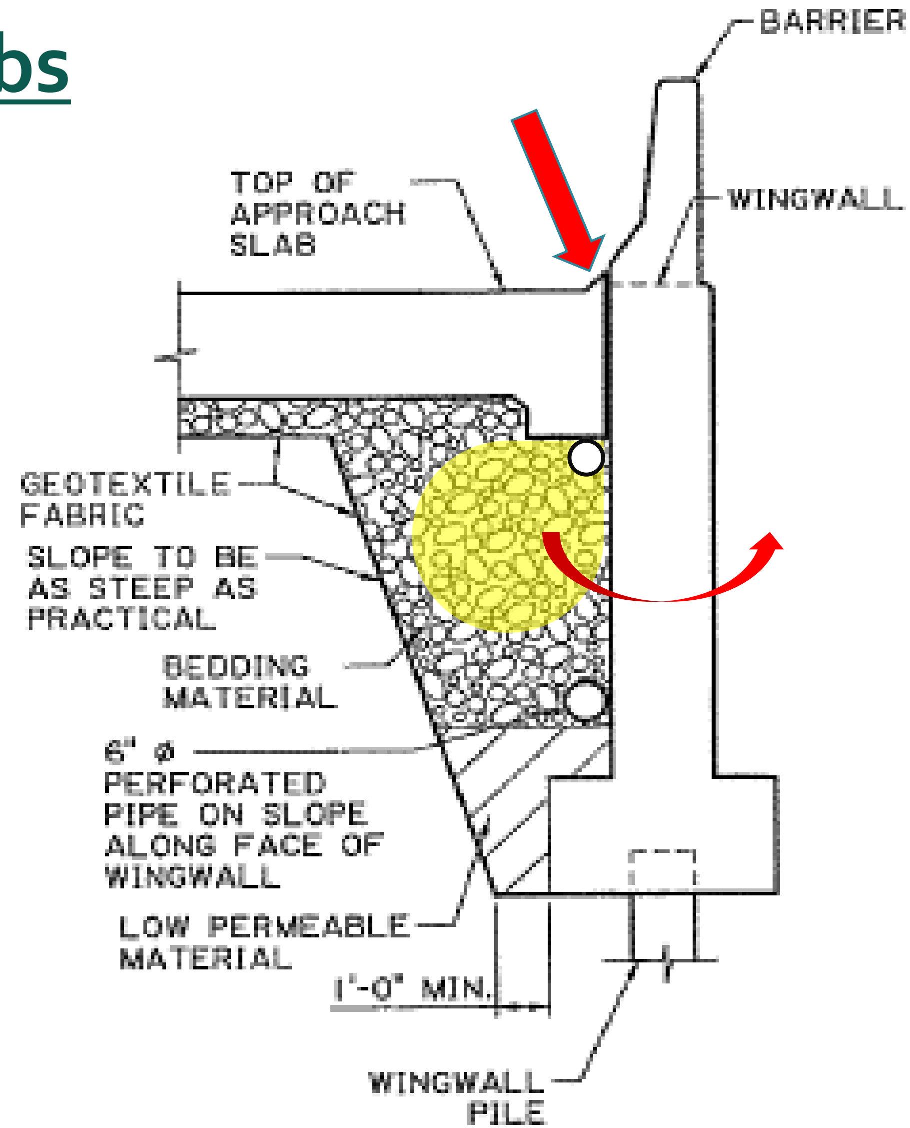
Expansion/Contraction

Joints Details

Maintenance Practices

Under Approach Slabs

Perforated Pipe along face of Wingwall



Drainage

Drainage

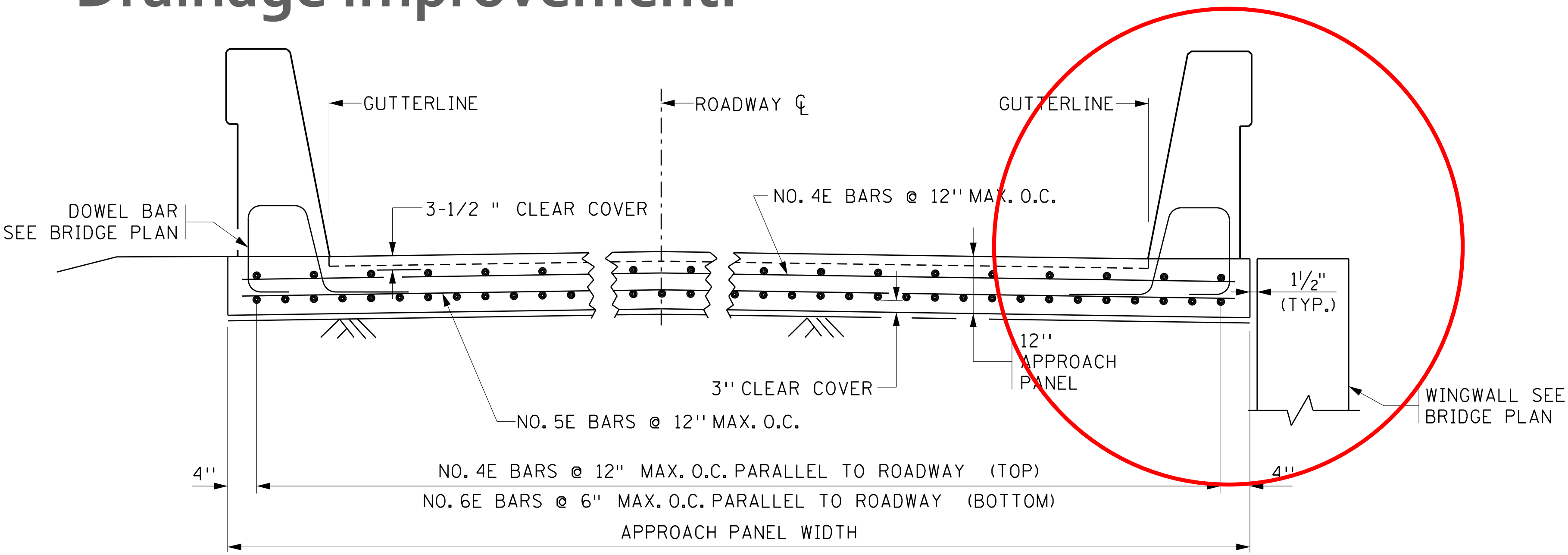
Drainage

Deck Drains

Some states do not allow drains on Bridge Decks

Over Approach Slabs

Barrier cast on top of approach panel Significant Drainage Improvement!



Drainage

Outboard Wingwalls

Barrier cast on top of approach panel

Drainage

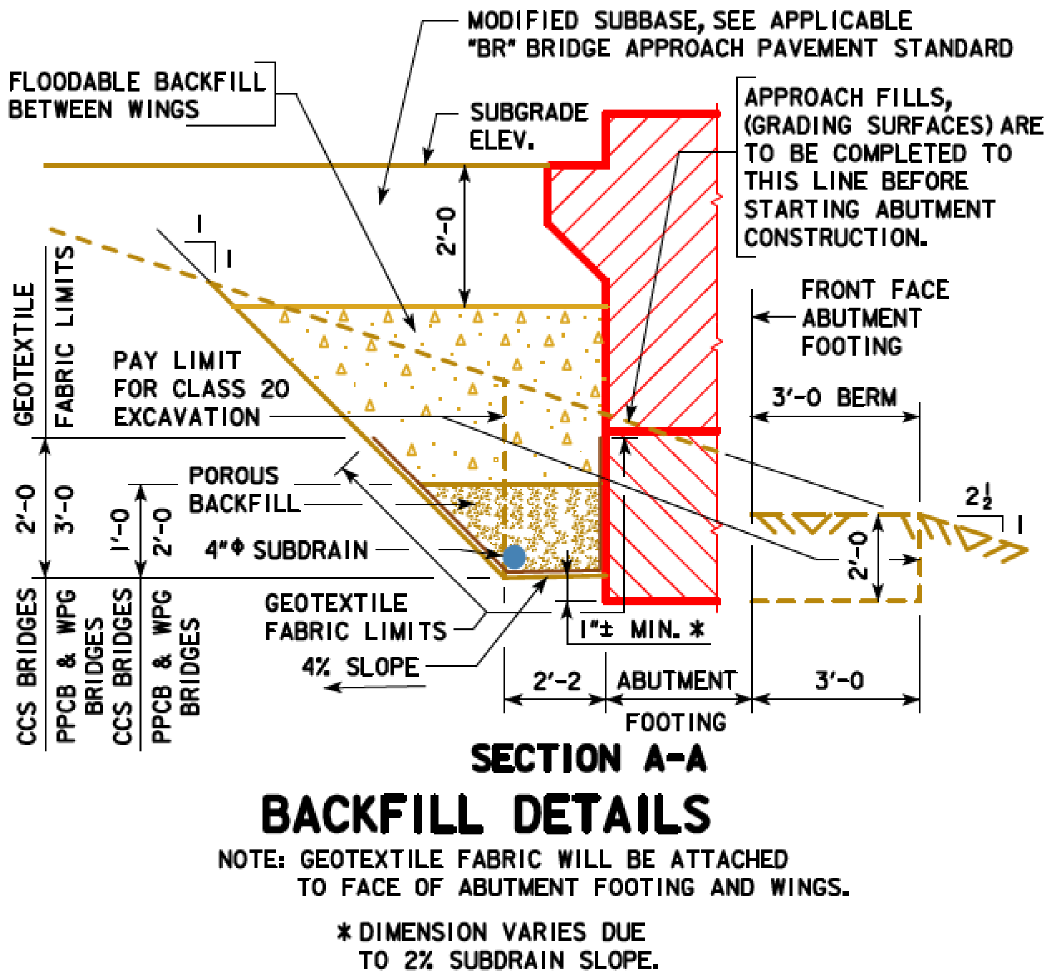
Outboard Wingwalls

Eliminates saturation of the backfill – reduces potential for settlement and voids.

Backfill and Compaction

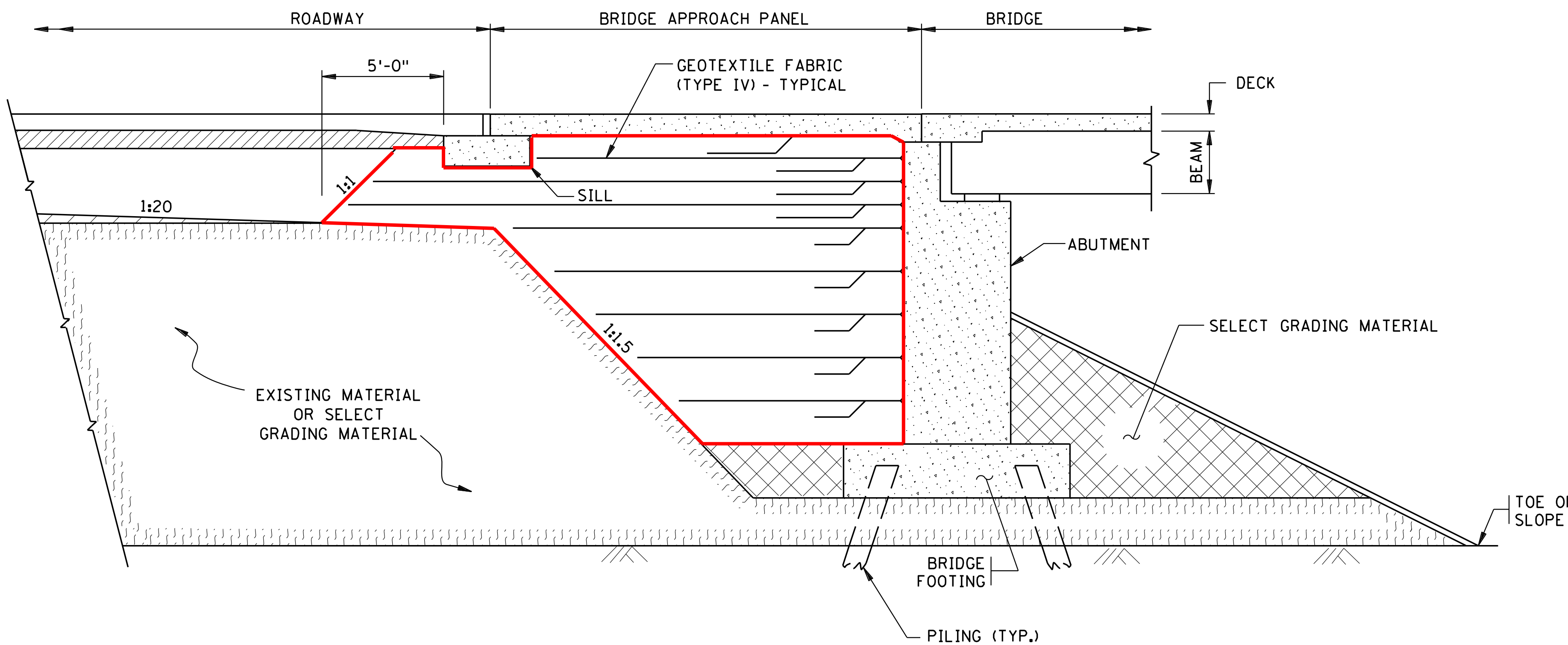
Proper Compaction is Critical to Prevent Settlement

Iowa
Flooded
Backfill



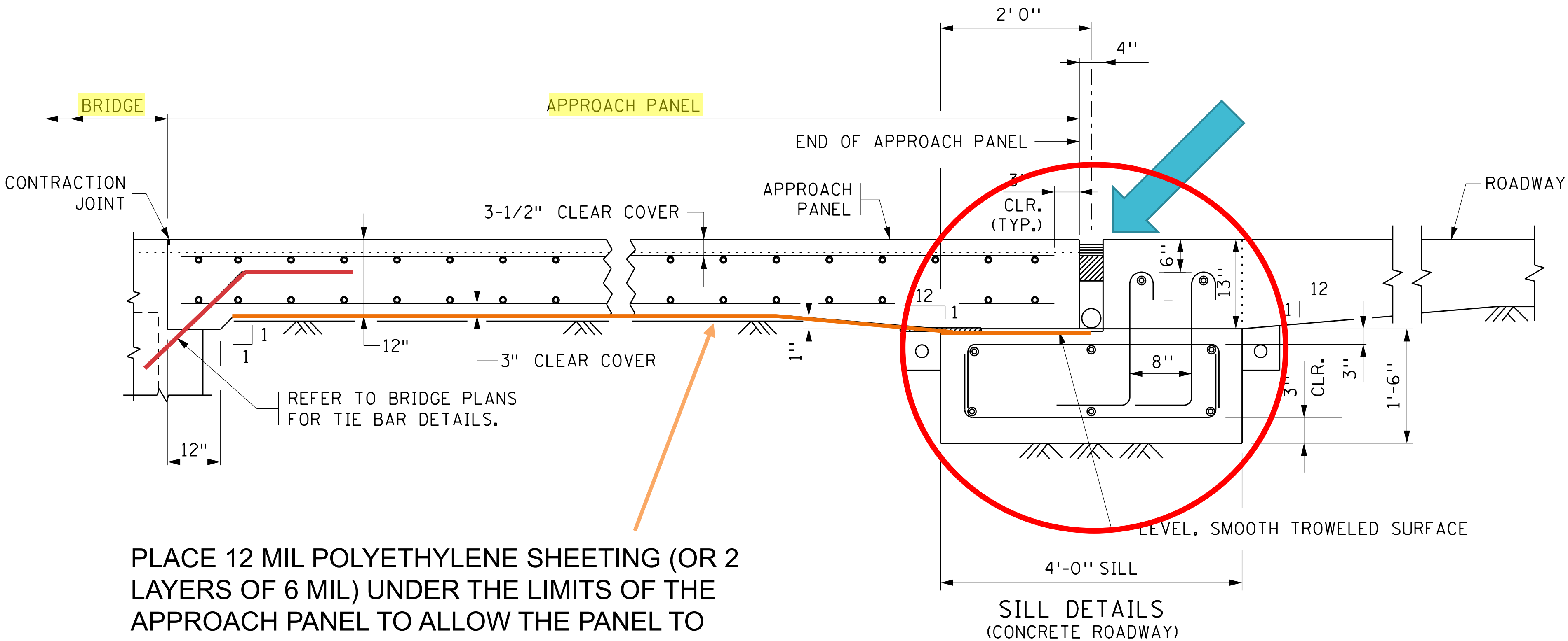
Backfill and Compaction

Proper Compaction is Critical to Prevent Settlement



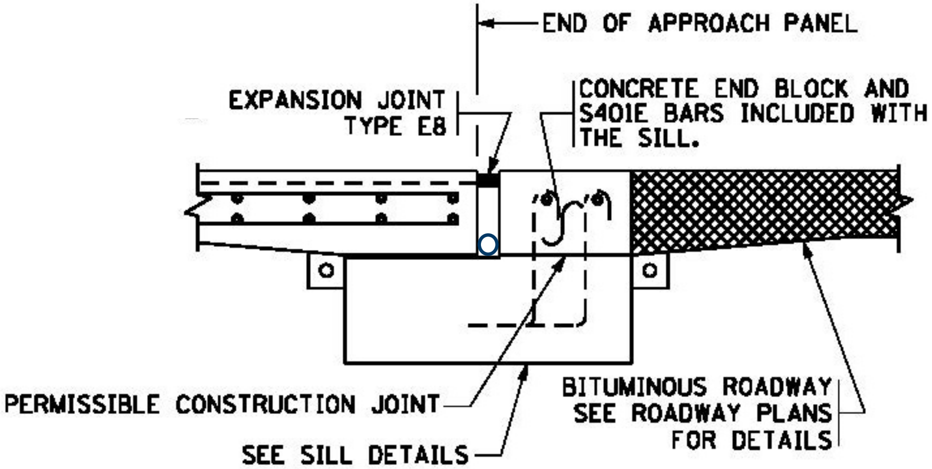
Geotextile Wraps

Expansion / Contraction of Approach Slab

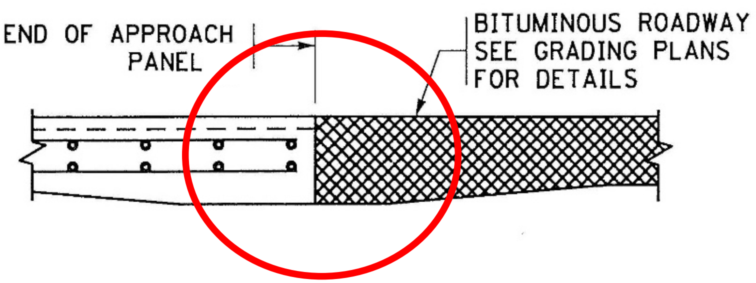


PLACE 12 MIL POLYETHYLENE SHEETING (OR 2 LAYERS OF 6 MIL) UNDER THE LIMITS OF THE APPROACH PANEL TO ALLOW THE PANEL TO MOVE LONGITUDINALLY ON THE GRADE.

Joint Details



High Volume / Long Bridge

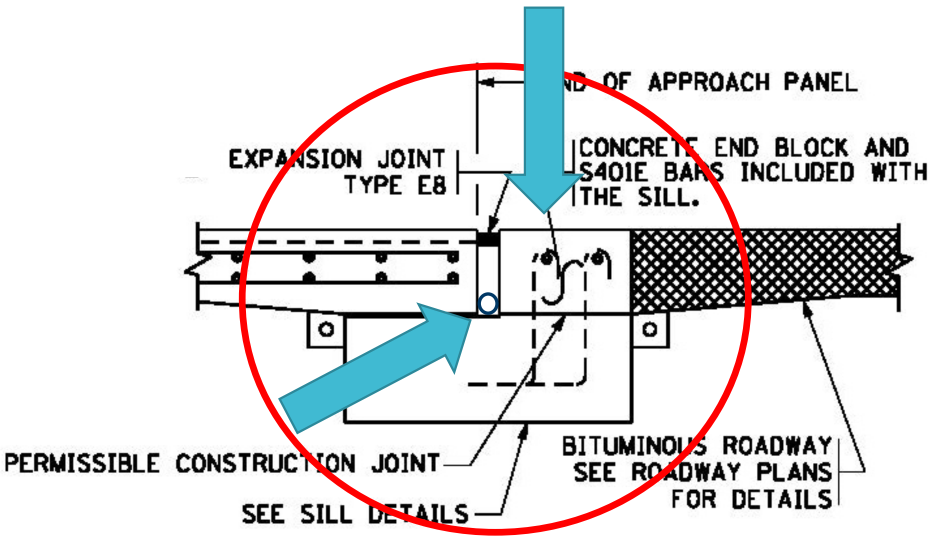


Low Volume / Short Bridge

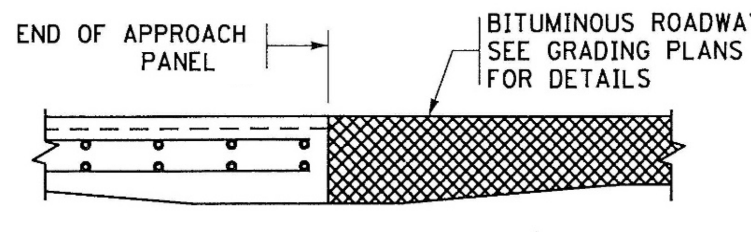
Joint Details

275’ Long Bridge , 500 ADT, 20 Years Old

Joint Details

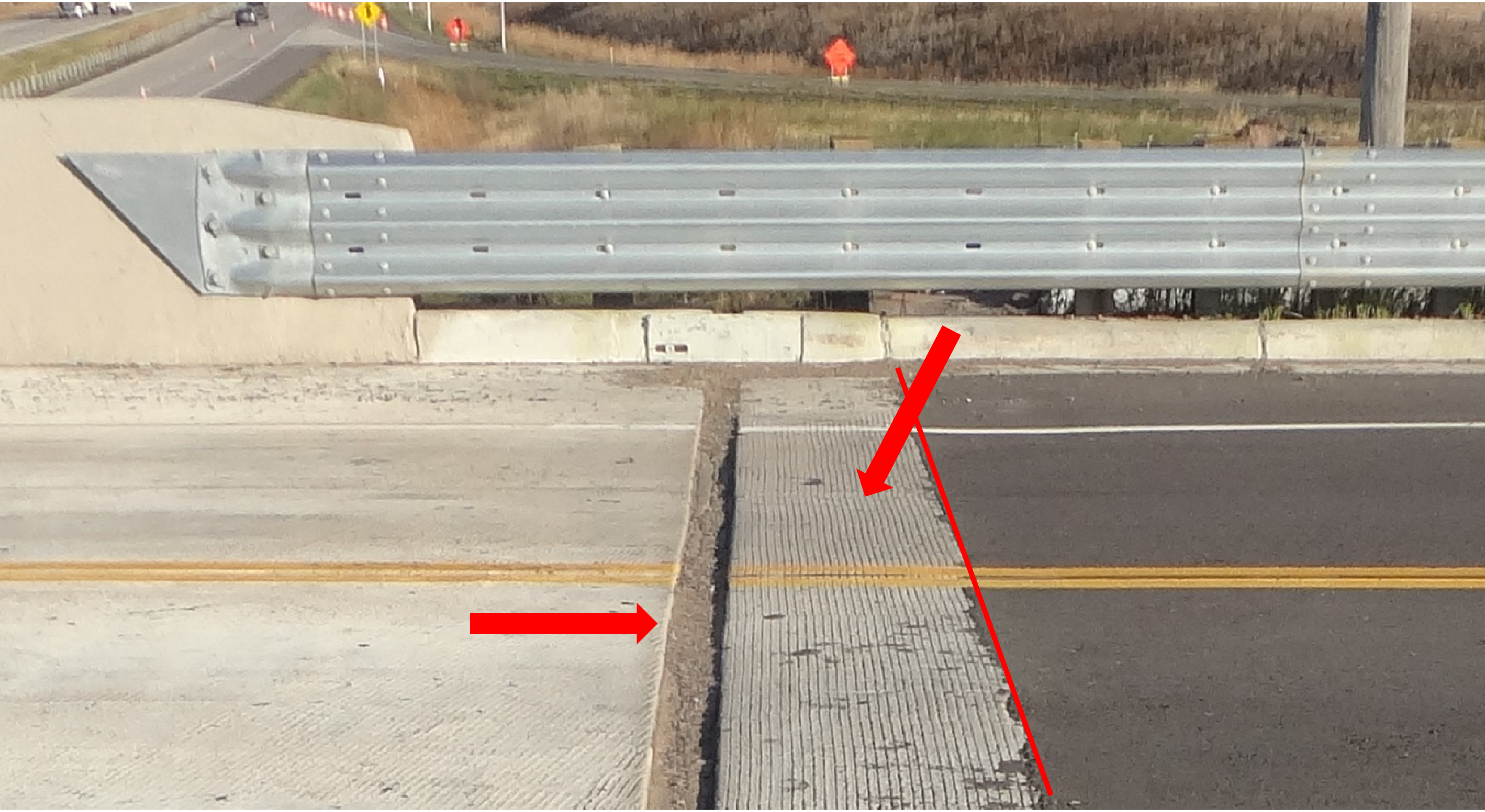


High Volume / Long Bridge



Low Volume / Short Bridge

Joint Details



Joint Details

Rubber Gland

Joint Details

Closed Cell Foam

Joint Details

Joint Details

Maintenance Activities

Maintenance Activities

Maintenance Activities

Tracking Performance

Summary of typical methods from States participating in the survey:

- Inspection reports
  - National Bridge Inventory (NBI) ratings
  - Typically performed bi-annually, unless specified to be more frequent
  - Condition states reported for specific bridge elements
  - Some track jointless structures separately from the rest of their inventory

Example: Barrell Bridge in York, Maine.

- Constructed in 2018
- Inspected in 2020

Typical NBI inspection form - MaineDOT

National Bridge Inventory

Status: 0 - ND   Bridge Name: BARRELL   Sufficiency Rating: 89.1

Inspections	
(90) INSPECTION DATE & (91) DESIGNATED INSPECTION FREQUENCY	24 11/03/2020
(92) CRITICAL FEATURE INSPECTION & (93) CFI DATE	
(92A) FRACTURE CRITICAL DETAIL	N
(92B) UNDERWATER INSPECTION	N
(92C) OTHER SPECIAL INSPECTION	N

Identification	
(1) STATE CODE	231 - Maine
(8) STRUCTURE NUMBER	3500
(5) INVENTORY ROUTE	
(5A) RECORD TYPE	1: Route carried "on" the structure
(5B) ROUTE SIGNING PREFIX	4 - COUNTY HIGHWAY
(5C) DESIGNATED LEVEL OF SERVICE	0 - None
(5) INVENTORY ROUTE	0
(5) INVENTORY ROUTE	0 - NOT APPLICABLE
(2) HIGHWAY AGENCY DISTRICT	01 - Southern
(3) COUNTY CODE	031 York
(4) PLACE CODE	87985
(6) FEATURES INTERSECTED	DOLLY GORDON BROOK
(7) FACILITY CARRIED	BEECH RIDGE ROAD
(9) LOCATION	0.5 MI W JCT US 1
(11) MILEPOINT	0.800
(12) BASE HIGHWAY NETWORK	Inventory Route is not on the Base Network
(13) LRS INVENTORY ROUTE, SUBROUTE	
(13A) LRS INVENTORY ROUTE	0003170664
(13B) SUBROUTE NUMBER	00
(16) LATITUDE	43.14286
(17) LONGITUDE	-70.70444
(98A) BORDER BRIDGE CODE	
(98B) PERCENT RESPONSIBILITY	0
(99) BORDER BRIDGE STRUCT NO.	n/a

Structure Type and Material	
(43) STRUCTURE TYPE, MAIN	
(43A) KIND OF MATERIAL/DESIGN	5 - Prestressed concrete
(43B) TYPE OF DESIGN/CONSTR	04 - Tee Beam
(44) STRUCTURE TYPE, APPROACH SPANS	
(44A) KIND OF MATERIAL/DESIGN	0 - Other
(44B) TYPE OF DESIGN/CONSTRUCTION	00 - Other
(45) NUMBER OF SPANS IN MAIN UNIT	1
(46) NUMBER OF APPROACH SPANS	0
(107) DECK STRUCTURE TYPE	1 - Concrete Cast-In-Place
(108) WEARING SURFACE/PROTECTIVE SYSTEMS	
(108A) WEARING SURFACE	2 - Integral Concrete (separate non-modified layer of concrete added to structural deck)
(108B) DECK MEMBRANE	0 - None
(108C) DECK PROTECTION	9 - Other

Typical NBI inspection form - MaineDOT

Condition	
(58) DECK	8 - Very Good Condition (no problems noted)
(59) SUPERSTRUCTURE	8 - Very Good Condition (no problems noted)
(60) SUBSTRUCTURE	8 - Very Good Condition (no problems noted)
(61) CHANNEL & CHANNEL PROTECTION	8 - Banks are protected
(62) CULVERT	N - Not Applicable

Load Rating and Posting	
(31) DESIGN LOAD	B - Greater than HL 93
(63) METHOD USED TO DETERMINE OPERATING RATING	8 - Load and Resistance Factor Rating (LRFR) rating report by rating factor (RF) method using HL-93 loadings.
(64) OPERATING RATING	2.68
(65) METHOD USED TO DETERMINE INVENTORY RATING	8 - Load and Resistance Factor Rating (LRFR) rating report by rating factor (RF) method using HL-93 loadings.
(66) INVENTORY RATING	2.07
(70) BRIDGE POSTING	5 - Equal to or above legal loads
(41) STRUCTURE OPEN/POSTED/CLOSED	A - Open

Appraisal	
(67) STRUCTURAL EVALUATION	8
(68) DECK GEOMETRY	4
(69) UNDERCLEARANCES, VERTICAL & HORIZONTAL	N
(71) WATERWAY ADEQUACY	6 - Occasional Overtopping of Approaches - Insignificant Delays
(72) APPROACH ROADWAY ALIGNMENT	8 - Equal to present desirable criteria
(36) TRAFFIC SAFETY FEATURE	
36A) BRIDGE RAILINGS:	1 - Meets acceptable standards
36B) TRANSITIONS:	1 - Meets acceptable standards
36C) APPROACH GUARDRAIL	1 - Meets acceptable standards

Typical NBI inspection form - MaineDOT

Element Inspection

	Environment	Total Quantity	Units	Condition State 1	Condition State 2	Condition State 3	Condition State 4
12 - Reinforced Concrete Deck	3 - Mod.	2444	sq. ft.	2444	0	0	0
109 - Prestressed Concrete Open Girder/Beam	3 - Mod.	304	ft.	304	0	0	0
215 - Reinforced Concrete Abutment	2 - Low	96	ft.	96	0	0	0
330 - Metal Bridge Railing	3 - Mod.	150	ft.	150	0	0	0
843 - Rigid Wearing Surface	3 - Mod.	2184	sq. ft.	1184	1000	0	0

Tracking Performance

- Instrumentation installed on recent bridge projects
  - Track bridge movements & stresses
  - Still receiving data, nothing processed yet

- Performance surveys
  - Maintenance crews documenting any reoccurring issues specific to jointless structures noticed during inspection
  - Design teams adjust/update details accordingly

Maintenance

Summary of typical methods from States participating in the survey:

- Most states have a scheduled maintenance program consisting of routine bridge cleaning/flushing, and minor repairs such as crack sealing.
  - Most states do not have a specific jointless bridge specific maintenance program.
- Significant maintenance is typically reactive, based on results from inspection programs

Today's Panelists

Moderator: Jason DeRuyver,

DEPARTMENT OF TRANSPORTATION

Ted Kniazewycz,
Tennessee DOT

Paul Rowenkamp,
Minnesota DOT

Devan Eaton,
Maine DOT

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