NATIONAL ACADEMIES Sciences Engineering Medicine

TRB TRANSPORTATION RESEARCH BOARD

TRB Webinar: Evaluating the Smoothness of Newly Constructed Concrete Bridge Decks

February 6, 2022

2:00 – 3:30 PM

NOVEMBER 2022 UPDATE

PDH Certification Information

1.5 Professional Development Hours (PDH) – see follow-up email

You must attend the entire webinar.

Questions? Contact Beth Ewoldsen at Bewoldsen@nas.edu

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.

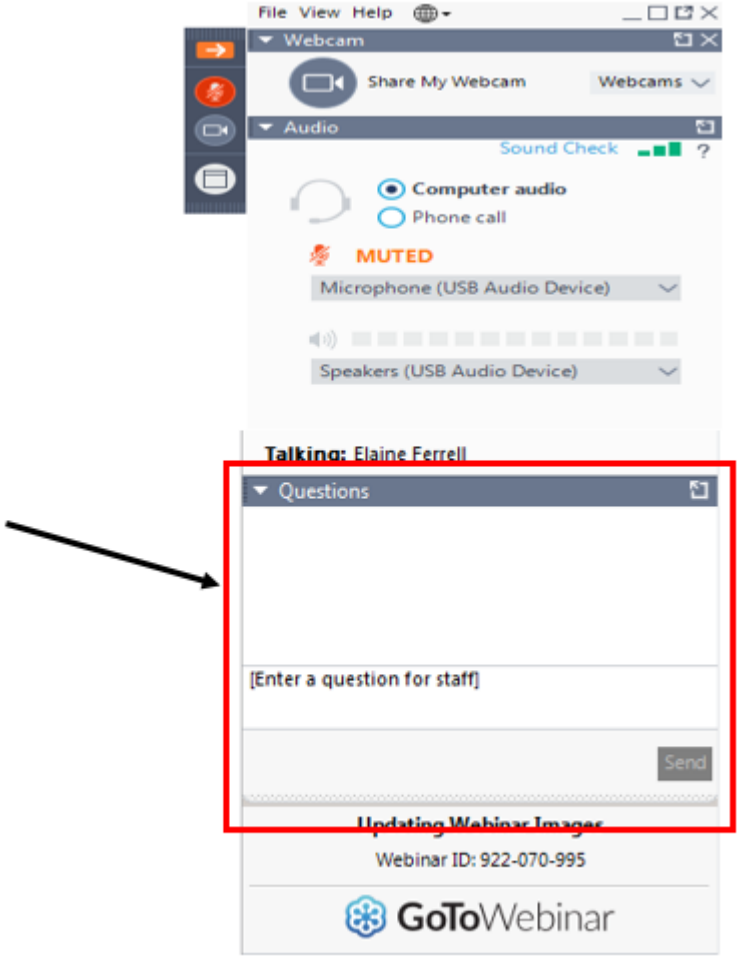
RCEP
REGISTERED CONTINUING EDUCATION PROGRAM

Learning Objectives

- Describe the methods used by state DOTs to evaluate the smoothness of newly constructed concrete bridge decks
- Identify the various equipment and methods that are used to measure smoothness of newly constructed concrete bridge decks
- Understand the indices used to quantify smoothness and the threshold limits established by DOTs for smoothness

Questions and Answers

- Please type your questions into your webinar control panel
- We will read your questions out loud, and answer as many as time allows



Today's presenters

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OHIO DEPARTMENT OF TRANSPORTATION

NATIONAL ACADEMIES *Sciences Engineering Medicine*

Evaluating the Smoothness of Newly Constructed Concrete Bridge Decks: Practices Used by State DOTs

Rohan Perera, PhD, PE
SME, Plymouth, MI

NCHRP Synthesis Topic: Practices for Ensuring the Smoothness of Concrete Bridge Decks

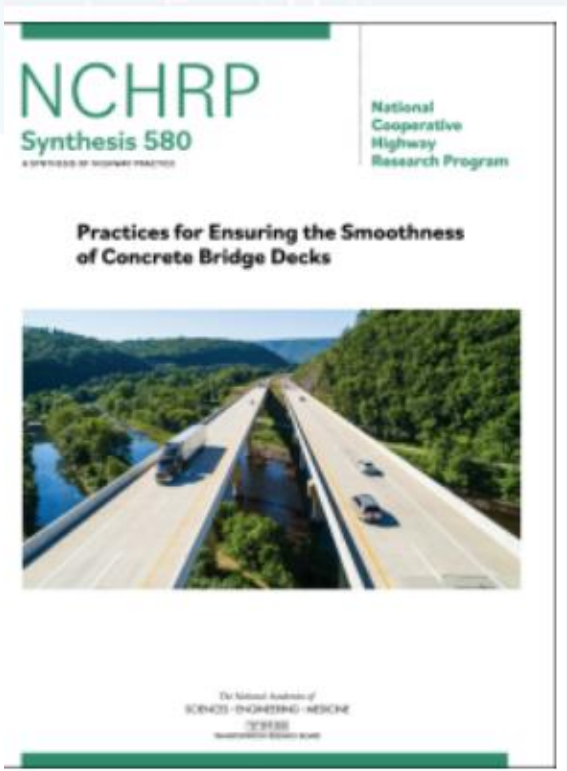
Objectives: Document Current DOT Practices

- **Methods used to evaluate the smoothness of a bridge deck after construction**
- **Procedures used to track the roughness of bridge decks over time**
- **Procedures used to maintain the smoothness of bridge decks over their life**

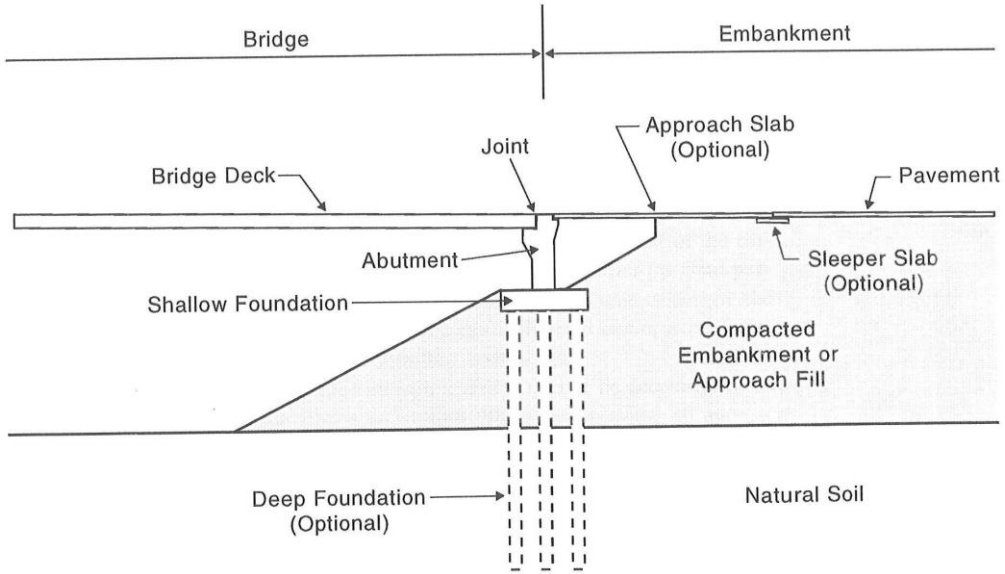
Survey for Synthesis

- Sent to 50 State DOTs and District of Columbia in March 2021
- Responses received from 39 State DOTs

NCHRP Synthesis 580 (2022)

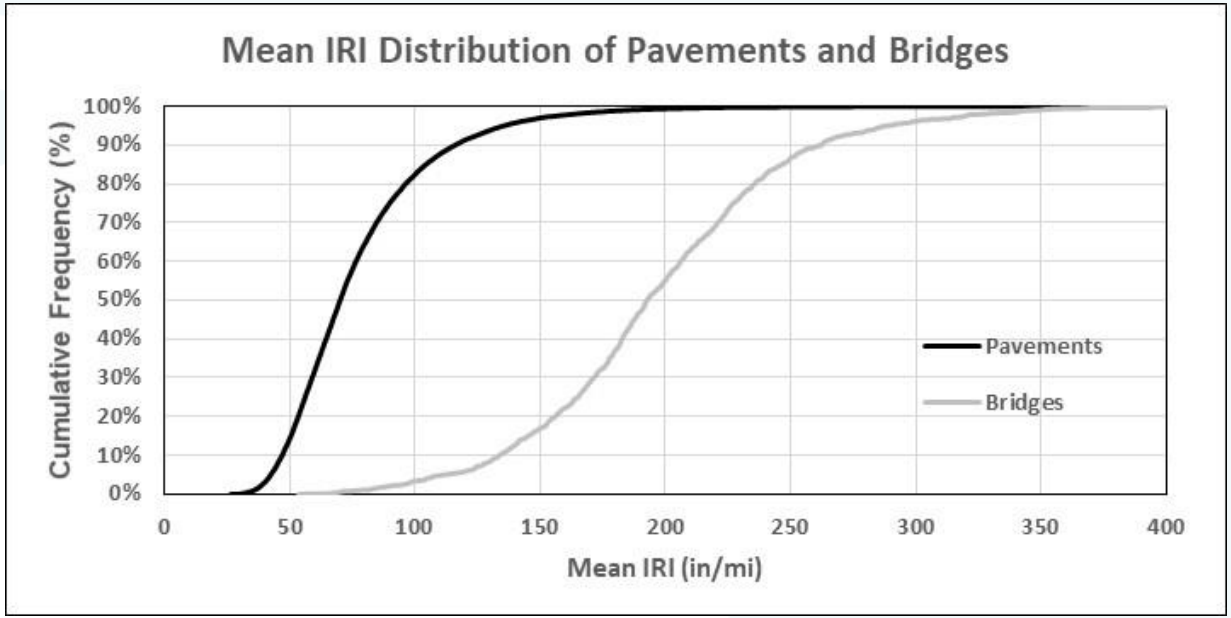


Elements of a Bridge and the Approach System



NCHRP, Briaud et. al. 1997

2001, Ohio DOT Ride Quality Study of Interstates



On average, Bridge Decks Approximately 2.5 Rougher than Pavements

Results from the Survey

Practices Used by DOTs to Evaluate the Smoothness of Newly Constructed Concrete Bridge Decks

Evaluating Smoothness of New Concrete Bridge Decks

METHOD	NO. DOTs	RESPONDING DOTs (%)
Smoothness not evaluated	2	5
Only a straightedge used	17	44
Rolling straightedge	3	7
Straightedge or rolling straightedge	1	3
Rolling straightedge simulation on inertial profiler data	1	3
Rolling straightedge simulation on walking profiler data	1	3
International Roughness Index (IRI)	6	15
Profilograph	8	20
TOTAL	39	100

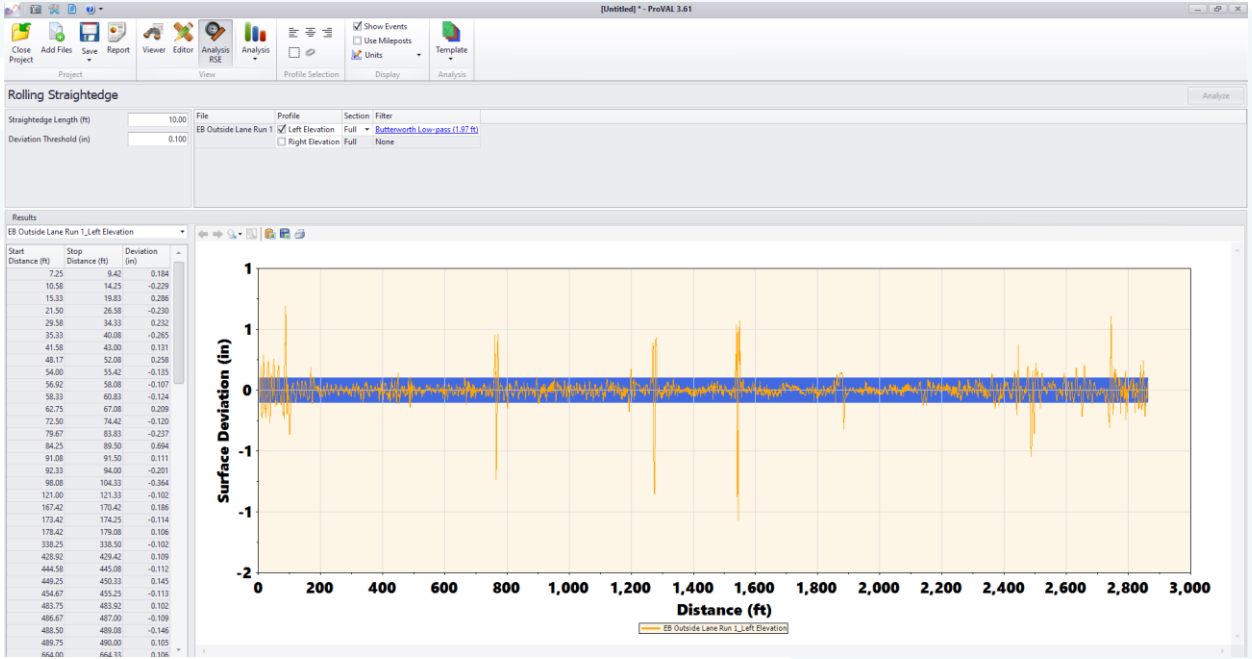
Straightedge Only (17 DOTs, 44% Respondents)

No. of DOTs	Length of Straightedge (ft)	Maximum Deviation (in)
10	10	1/8
3	10	3/16
1	10	3/8
2	10	1/4
1	12	3/16

Rolling Straightedge (3 DOTs, 7% Respondents)

10-foot Rolling Straightedge, 1/8” Deviation

Rolling Straightedge Simulation on Inertial Profiler Data (1 DOT, 3% Respondents)



10-foot Straightedge, 1/8” Deviation

Inertial Profiler

Rolling Straightedge Simulation on Walking Profiler Data (1 DOT, 3% Respondents)

ICC

SSI

10-foot Straightedge, 1/8” Deviation

$$\text{Lot \% Defective Length} = \frac{\text{Length out of Tolerance Both Wheelpath}}{\text{Total Length of Wheelpaths}} \times 100$$

Negative Pay Adjustments Based on % Defective Length for Values Over 9%

Profilograph Based (8 DOTs, 20% Respondents)

Profilograph Based (8 DOTs, 20% Respondents)

METHOD OF OBTAINING PROFILOGRAPH DATA	NO. DOTs
California Profilograph	4
Modified California Profilograph	1
California Profilograph Simulation on Inertial Profiler Data	1
California Profilograph or Simulation of Profilograph on Inertial Profiler Data	1
Rainhart Profilograph Simulation on Inertial Profiler Data	1

Profile Index Requirement and a Bump Criterion

International Roughness Index (IRI) Based

- Six DOTs (MI, MN, NV, OH, TN, UT) use an IRI-based specification
- AL DOT: IRI-based specification used on one project
- LA DOT: Has a draft IRI-based specification
- Note: Many DOTs that do not have an IRI-based specification for bridge decks do have an IRI-based specification for concrete pavements

International Roughness Index (IRI)

- Data collected with an inertial profiler
- IRI computed from collected data on each wheelpath using a computer program and averaged to obtain Mean IRI (MIRI)

IRI Based, Limits of Application

STATE DOT	LIMITS OF APPLICATION OF SPECIFICATION	NO. DOTs
MI and AL	Bridge deck only	2
MN and LA	Bridge deck and approach slab	2
TN	Bridge deck and a specified distance on both sides of the bridge deck	1
NV, UT, OH	Bridge deck, approach slab, and a specified distance of pavement before the entry approach slab and after the exit approach slab	3

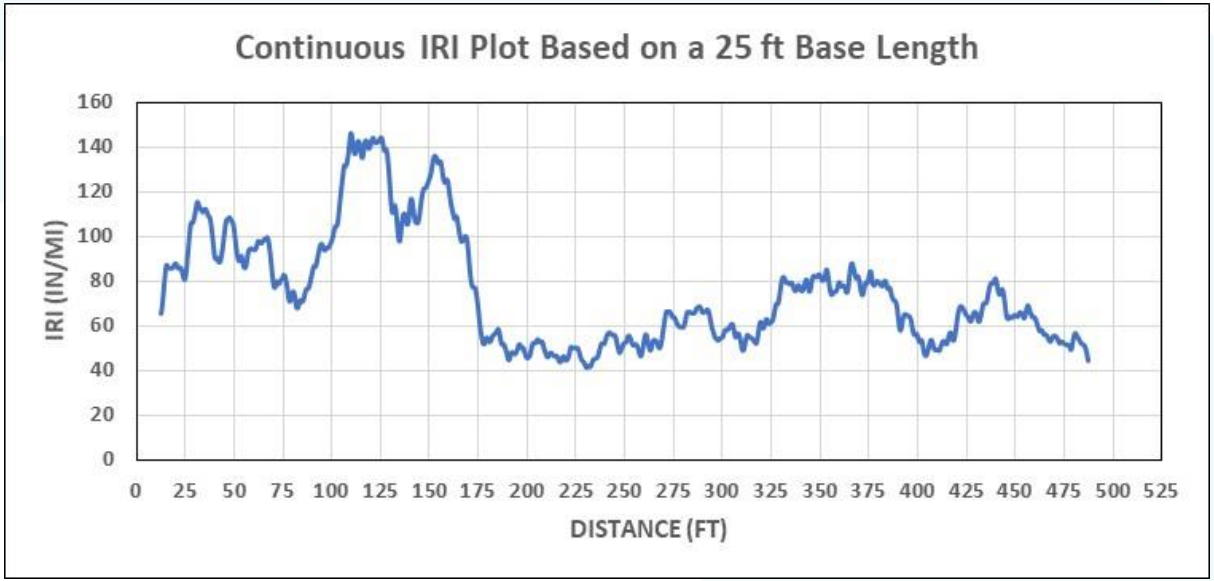
IRI-Based, Mean IRI (MIRI Reporting)

DOT	MIRI REPORTING INTERVAL OR REQUIREMENT	NO. DOTs
MI and TN	Entire profiled lane	2
AL, MN, UT	0.1-mile intervals	3
NV and OH	No MIRI requirement. Requirement based on localized roughness	2
LA	264 ft intervals	1

IRI-Based, Allowable MIRI

DOT	MIRI REPORTING REQUIREMENTS	MIRI REQUIREMENT
MI and TN	Entire profiled lane of bridge	< 130 in/mi
AL	0.1-mile intervals	< 120 in/mi
MN	0.1-mile intervals	< 60 in/mi
UT	0.1-mile intervals	< 90 in/mi
LA	264 ft intervals	< 120 in/mi

Localized Roughness, IRI



IRI at any location is average IRI over 25 feet centered at that location (i.e., IRI at 100 ft is average IRI from 87.5 to 112.5 ft)

IRI-Based, Localized Roughness

DOT	LOCALIZED ROUGHNESS REQUIREMENT
Alabama	25-ft moving average IRI
Louisiana	25-ft moving average IRI
Michigan	Straightedge based
Minnesota	Profilograph based
Nevada	25-ft moving average IRI
Ohio	25-ft moving average IRI
Tennessee	25-ft moving average IRI
Utah	25-ft moving average IRI

IRI-Based, 25-Ft Moving Average Requirements

DOT	MAXIMUM ALLOWABLE IRI LOCALIZED ROUGHNESS
LA	180 in/mi no joint, 250 in/mi joint
NV	175 in/mi
OH	Histogram Based
TN	> 45 mph: 190 in/mi, < 45 mph: 250 in/mi, Expansion Joint - 350 in/mi
UT	250 in/mi, Must be over 15 ft

Thank You!!

IDOT'S PATH TO SMOOTHER BRIDGES

John Senger, P.E.

Engineer of Pavement Technology

Illinois Department of Transportation

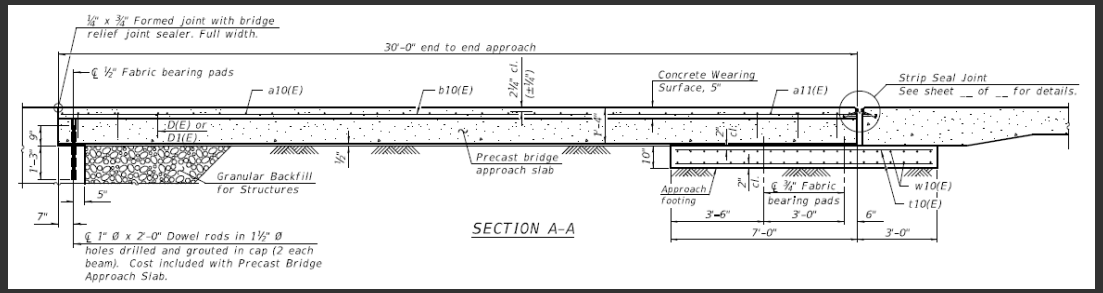
"DEVELOPMENT OF A BRIDGE SMOOTHNESS SPECIFICATION FOR ILLINOIS DOT"

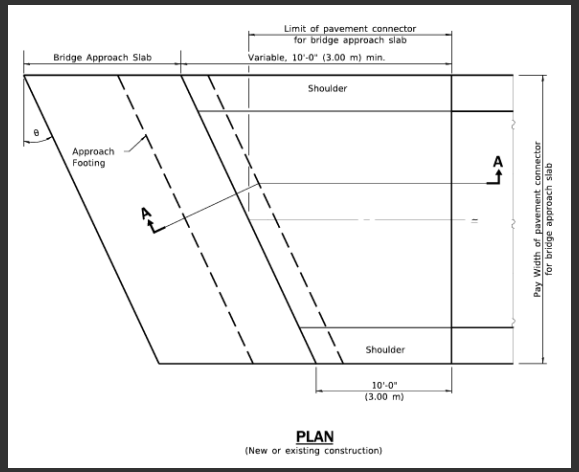
- The Illinois Department of Transportation and the University of Illinois completed a research project in May of 2001.
  - This project measured the ride quality (IRI and PI) of 20 bridge decks within Illinois.
  - Used a lightweight profiler for the data collection.
  - Final recommendation was an IRI based specification with sublots of 0.05 miles
    - Sublots greater than 150 in/mi. must be corrected
    - Bumps or dips greater than 0.4 inch must be corrected
    - 50 feet in front of approach pavement to 50 behind the opposite approach pavement

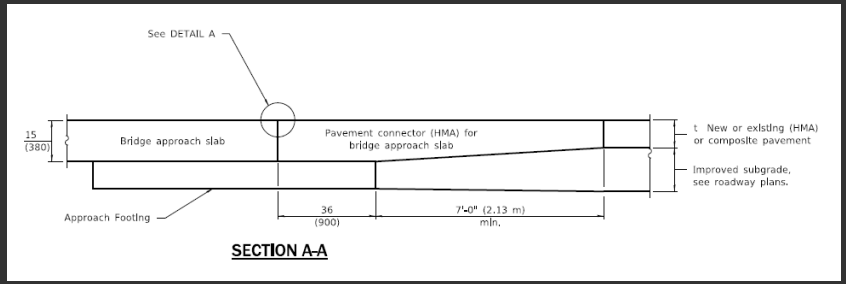
IDOT'S FIRST BRIDGE SMOOTHNESS SPECIFICATION

- Bridge Section = Bridge deck + Approaches + Connector Pavement
- Grinding head must be 4' wide with 50 blades per foot
- Bridge decks and approach pavements are placed ¼" thicker to accommodate grinding
- Testing equipment shall be California Profilograph or equivalent
- 0.0 inch blanking band
- All bumps 0.30 inch and greater must be corrected at the contractor's cost
- Incentives and disincentives were based on the final average PI of the section
- Any bridge section with an average PI greater than 35 in./mi. shall be corrected to 35 in./mi. or less.

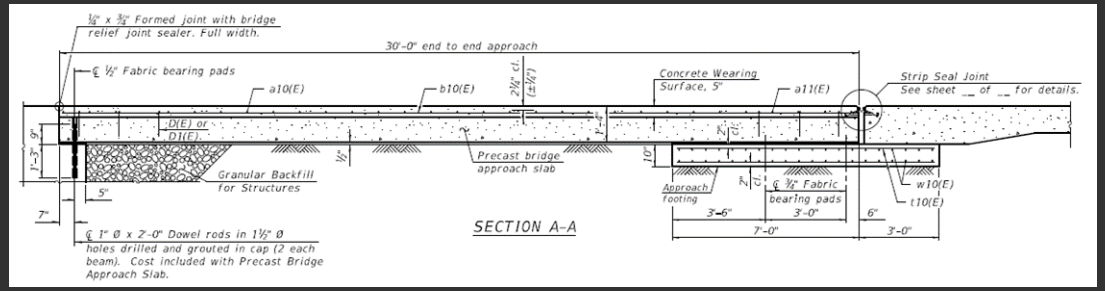
PIECES OF BRIDGE SECTION NEXT TO HMA PAVEMENT

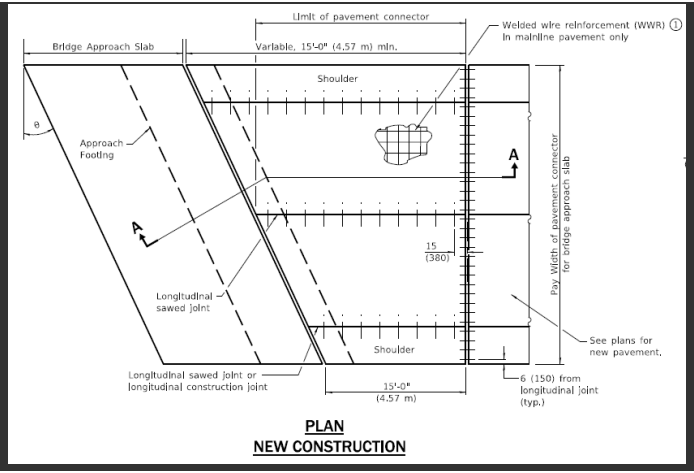


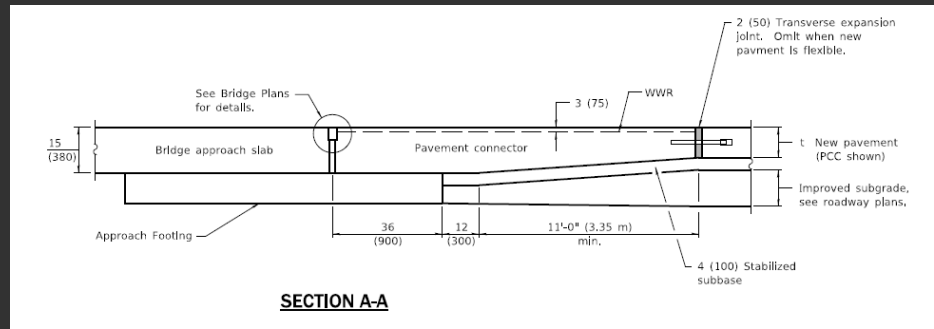




PIECES OF BRIDGE SECTION NEXT TO PCC PAVEMENT







SMOOTHNESS ASSESSMENT SCHEDULE

Profile Index (in./mi.) per Bridge Section	Smoothness Assessment per Bridge Section
15.0 or less	+$7,500
>15.0 to 18.0	+$5,000
>18.0 to 20.0	+$2,500
>20.0 to 35.0	+$0.00
>35.0 to 45.0*	+$0.00
>45.0*	-$5,000

* Must be corrected to 35 in./mi. or less

LAST VERSION OF PROFILE INDEX

- Bridge Section = Bridge deck + Approaches + Connector Pavement
- Grinding head must be 4’ wide with 50 blades per foot
- Bridge decks and approach pavements are placed ¼” thicker to accommodate grinding
- Testing equipment shall be Inertial Profiler System capable of calculating PI
- 0.0 inch blanking band
- All bumps 0.30 inch and greater must be corrected at the contractor’s cost
- Any bridge section with an average PI greater than 25 in./mi. shall be corrected to 25 in./mi. or less.

GUIDELINES FOR BRIDGE SMOOTHNESS

- Required Applications
  - Interstate Bridges that are greater than 150’ in length and over 10,000 ADT.
- Recommended Applications
  - State routes over 10,000 ADT, structure is longer than 150’, and posted speed limit is greater than 45 MPH.
  - Interstate ramp structures with ADT greater than 10,000

IRI BASED SPECIFICATION

- Adopted in 2022
- Bridge section from connector pavement to connector pavement
- Bridge decks and approach pavements are placed ¼" thicker to accommodate grinding
- No incentives and disincentives
- Final surface must have a continuous MRI below 200 in./mi. over 25 ft

REASONS FOR TRANSITION

- In 2021, IDOT moved from PI to IRI for pavement smoothness acceptance
- Not all bridge sections as defined by the specification are equal
- PI does not offer metric like continuous IRI
- Having the bridge smoothness specifications match pavement specifications both in indices and settings helps simply measurements.
  - Both using International Roughness Index
  - Pavement's threshold for areas of localized roughness now at 200 in./mi.

Smoothness of New Concrete Bridge Decks – Ohio DOT Practices

TRB Webinar: Evaluating the Smoothness of Newly Constructed Bridge Decks

DAVID T. FLOOD, PE

STATE CONSTRUCTION STRUCTURAL ENGINEER

OHIO DEPARTMENT OF TRANSPORTATION

History of Smoothness Specifications in Ohio

Ohio DOT (ODOT) historically used rolling straightedge for smoothness evaluation of new concrete bridge decks.

ODOT historically used Profile Index (PI) computed from California Profilograph measurements to evaluate smoothness of new pavements.

In 2007 ODOT transitioned from using PI to IRI for to evaluate smoothness of new pavements.

Experimental Plan Notes for Concrete Bridge Decks 2005 - 2011

Experimental IRI specification used on some non-interstate projects from 2005 to 2006.

Experimental plan note used on a few interstate projects from 2007 to 2011.

Research Project 2008-2011 with Iowa State: Identification and Evaluation of Pavement-Bridge Interface Ride Quality Improvements and Corrective Strategies, Iowa State University, Dr. Brent Phares, PI

- Defined Bridge Encounter: 25 ft of pavement before entry approach slab, entry approach slab, bridge deck, exit approach slab, 25 ft of pavement after exit approach slab.
- Overall Mean IRI (MIRI) of lane < 130 in/mile, if over that limit must correct .
- Positive pay adjustment applicable if MIRI < 130 in/mi, with maximum pay adjustment paid for a MIRI of 80 in/mi
- No localized roughness requirement in specification.

January 2012 - First Smoothness Specification for Bridges and Approaches, Proposal Note 555

Could be used on all bridges irrespective of the type of bridge (integral, semi-integral, expansion joint structure, suspension, cable-stayed).

Specification applied if Bridge Encounter > 265 feet.

Overall lane MIRI < 130 in/mi, if over must correct to 100 in/mi.

No localized roughness criteria.

No pay adjustments.

Each district in ODOT (ODOT has 12 districts) can elect to use this specification.

History of Proposal Note 555

Surface Smoothness for Bridges and Approaches PN555

- April 2013
- Localized roughness limit IRI 250 Inches/mile in 25 feet
- Localized roughness limit IRI 350 Inches/mile in 25 feet in presence of steel armor
- No overall IRI requirement if encounter is less than 265’ in length

- April 2014
- Required Corrective Action Plan (CAP) but no details
- If PN 555 used with PN 420, PN 420 governs localized roughness in overlap of specifications

History of Proposal Note 555

Surface Smoothness for Bridges and Approaches PN555

- April 2015
  - Detailed CAP required with guidance documents
- October 2017
  - District Construction Engineer determined deductions if specification not met after corrections
- January 2020
  - Corrective Action became a “Punch List” item with possibility of additional damages if not completed in reasonable time

January 2021 – Update – Why the Change

Higher percentage of projects not meeting PN 555 goals.

Contractors and ODOT want consistent negative pay adjustment

Clarify our intent to provide better profile before grinding

Department wanted similar criteria to Roadway Pavement with Positive and Negative adjustments.

Need clarifications on handling expansion joints like polymer modified and strip seals without armor.

January 2021 – Update – What Changed

MIRI was removed and replaced with just the localized roughness

Localized roughness defined in Supplement 1112 App. D.

Added Positive and Negative Pay adjustments.

Supplement 1112 was rewritten to provide steps to do the positive and negative adjustments.

Clarified all costs to provide corrective action is borne by contractor (Ex. MOT, Pavement Markings etc.)

Positive pay adjustment only if entire bridge encounter does not have any localized IRI violations after correction

Negative pay adjustment is based on post correction. The contractor may correct out of a negative correction but not into additional positive pay adjustments.

Added language for handling joints.

ODOT Supplement 1112

Provides Guidelines for use of ProVAL software for measuring and evaluating IRI for bridge encounters

Provides link to free ProVAL software

Provides directions for filtering and cropping a road profile before analyzing it for localized IRI roughness in each wheel path.

Example for Corrective Action Plan Development

Requirements for localized roughness and localized roughness histogram analysis with ProVAL

Example to copy into ODOT excel Pay Template

Engineer Verification

ODOT Supplement 1112

Appendix A – Project Road Profile Log Sheet

Appendix B – Instructions for Profile Log Sheet

Appendix C – Corrective Action Plan Requirements

Appendix D – Localized Roughness and Localized Roughness Histogram Discussion.

ODOT Supplement 1058

Requirements for Calibration of Equipment and Operators.

All Profilers and Operators approved by Department.

Annual Certification occurs first full week of May.

Approval valid for 1 year.

All Operators attend Federal Highway Administration NHI – 131100 Pavement Smoothness: *Use of Inertial Profiler Measurements for Construction QC or equivalent approved by ODOT*

Must pass a test of 40 questions. Minimum 32 score to pass.

Engineer Field Verifies prior to use.

Pay Adjustment

Table 1 - Pay Adjustment – No Steel Armor Expansion Joint Systems			
IRI	**Approx. Area Under the Curve (AAUC)**	**Factored Bid Cost (FBC)**	**Pay Adjustment (PA)**
IRI > 600	**Contractor submits corrective action plan.**		
550 < IRI ≤ 600	**AAUC = -325 * $L_{550-600}$**	**FBC = BC/1000**	**PA = AAUC*FBC**
500 < IRI ≤ 550	**AAUC = -275 * $L_{500-550}$**		
450 < IRI ≤ 500	**AAUC = -225 * $L_{450-500}$**		
400 < IRI ≤ 450	**AAUC = -175 * $L_{400-450}$**	**FBC = BC/2000**	
350 < IRI ≤ 400	**AAUC = -125 * $L_{350-400}$**		
300 < IRI ≤ 350	**AAUC = -75* $L_{300-350}$**		
250 < IRI ≤ 300	**AAUC = -25 * $L_{250-300}$**		
200 < IRI ≤ 250	**No Pay Adjustment**		
150 < IRI ≤ 200	**AAUC = 25 * $L_{150-200}$**	**FBC = BC/4000**	**PA = AAUC*FBC**
100 < IRI ≤ 150	**AAUC = 75 * $L_{100-150}$**		
50 < IRI ≤ 100	**AAUC = 125 * L_{50-100}**		
0 < IRI ≤ 50	**AAUC = 175 * L_{0-50}**		

Notes:

L_{i-j} = Total length (ft) of encounter with $i < IRI \leq j$ (e.g. $L_{200-250}$ for $200 < IRI \leq 250$)

BC bridge decks = Unit Bid Cost ($/yd^3) of superstructure concrete deck

PN 555 – Results to Date

Adjustments in 2022 were as expected. Higher percentage of positive adjustments as predicted.

The Department will evaluate the area under the curve method after another year of data with positive and negative adjustments.

Currently no complaints from Districts nor Contractors.

Less structures not meeting specification.

Summary of ODOT's Lessons Learned from Smoothness Specifications

Educate your agency construction staff. Have specialists in all parts of your state. (example - ODOT IRI Smoothness Specification and ProVAL Software User's Group).

Educate and work with your Contractors. (ODOT has contractors involved in our specification process and user groups)

Communicate with your agency and contractors regularly.

Update and implement improvements from your feedback from Contractor and your staff.

Have a Supplement like 1058 for approval for Equipment and Operators. Also have staff that can QA projects as needed during the year.

Have a Supplement like 1112 that provides clear directions on how to perform IRI and also provide information for non-ProVAL users.

Summary of ODOT's Lessons Learned from Smoothness Specifications

Positive and Negative Adjustments have value for your long-term specification. Provides a consistent path for ODOT administration of a project and maintains quality standards for Bridge Structures.

Smooth Bridges have value.

- Lowers Maintenance Cost.
- Improves user cost and safety.
- Improves user satisfaction.

Today's presenters

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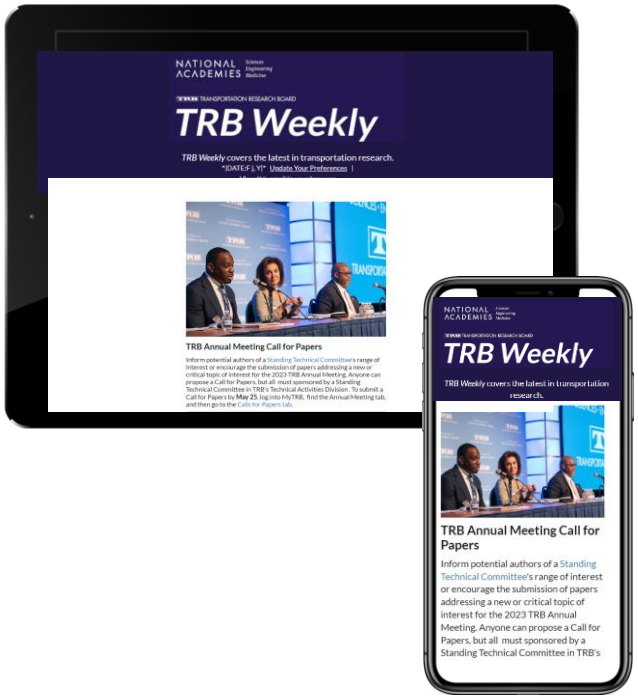

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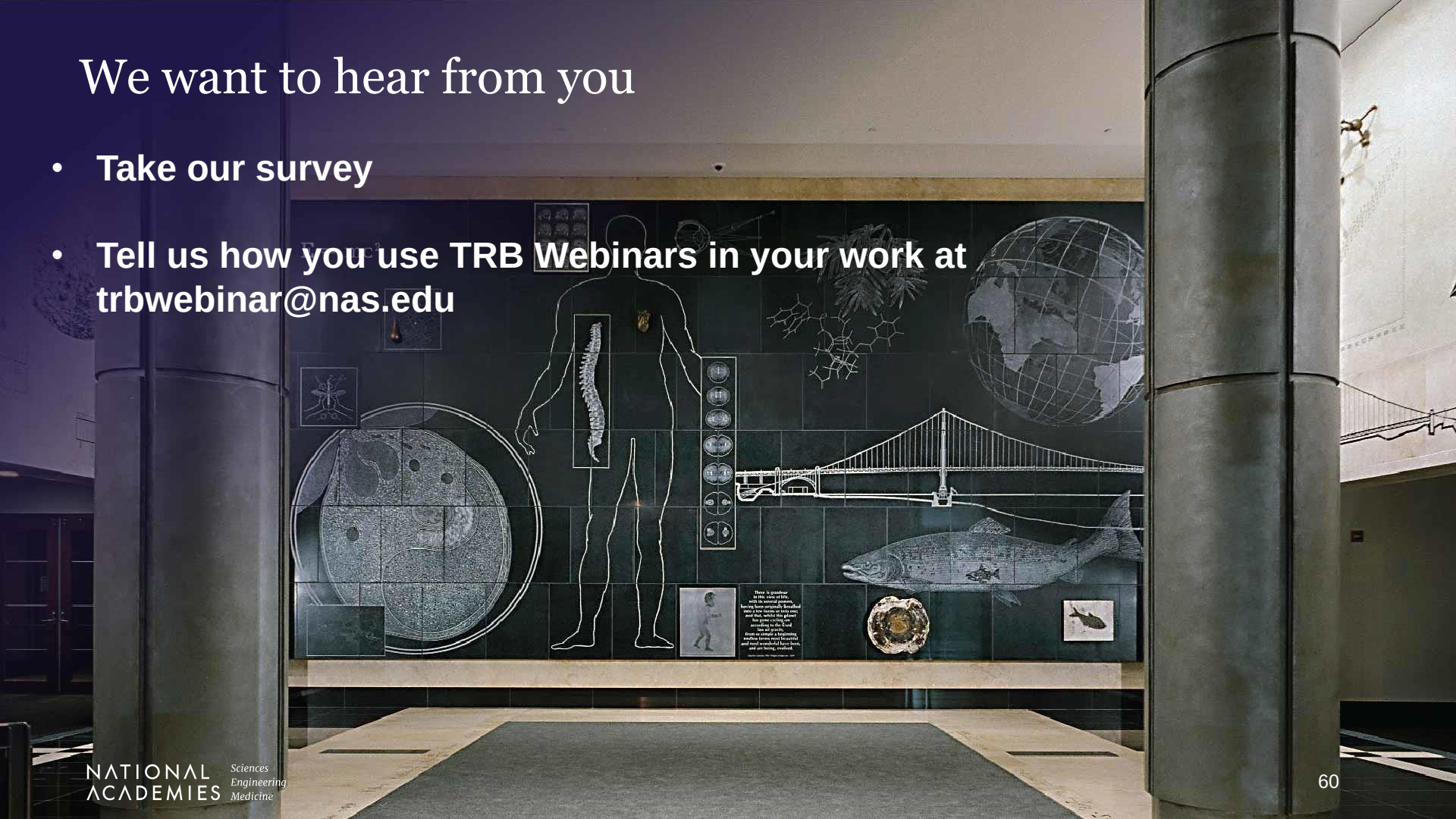

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